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PAGE

Eighteenth Annual Meeting of the Middle States Branch of the American Association of Economic Entomologists
Part I Business Meeting 1009

Part II
Lizards as Predators of the Beet Leafhopper
*E. P. Breakey* and *M. J. Janes* 1011
Insect Tolerance
*R. L. Webster* 1016
Detection and Determination of Fluorine Oil on Citrus Following Spraying
*A. F. Swain* and *Don Green* 1021
Study of Auxiliary Gases for Increasing the Toxicity of Hydrocyanic Gas
*F. S. Fisher, A. F. Swain* and *D. N. Eldred* 1031
Laboratory Experiments with Various Fumigants against the Wireworm, *Limonius californicus* Mann.
*Russell H. Lehman* 1042
Airplane Liquid Spraying
*Frank B. Herbert* 1052
A Practical Test of Chemically Treated Bands for the Control of the Codling Moth
*E. J. Newcomer, A. R. Reiff* and *F. P. Dean* 1053
Some Notes on the Biology of the Pea Weevil, *Bruchus pisorum* L., at Moscow, Idaho
*T. A. Brindley* 1058
Local Dispersal of the Pea Weevil
*A. O. Larson, T. A. Brindley* and *Frank G. Hinman* 1063
Temperature as a Possible Limiting Factor in the Northern Spread of the Colorado Potato Beetle
*G. Allen Mail* and *R. W. Salt* 1068
The Identity of Two Lygus Pests
*W. Earl Shull* 1076
Insects Collected in Flight Traps in the Vicinity of Moscow, Idaho
*Paul A. Rice* 1079
A Method for Temporary Inhibition of Coagulation of the Blood of Insects
*W. Earl Shull* and *Paul L. Rice* 1088
Western Willow Tingid, *Corythucha salicata* Gibson, in Oregon
*H. C. Thompson* and *Kwan Lan Wong* 1090
Some Tests with Fluorine Compounds against the Pepper Weevil, *Anthonomus eugenii* Cano
*J. C. Elmore* 1095
Efficient Agitation in the Spray Tank
*Arthur D. Borden* 1106
Notes on the Life History of the Apple Maggot in Wisconsin
*T. C. Allen* and *C. L. Fluke* 1108
Field Studies with Fish Oils as Destroyers of Overwintering Codling Moth Larvae
*F. M. Thompson* and *H. N. Worthley* 1112
Investigations Regarding Bluegrass Webworms in Turf
*H. T. A. North* and *G. A. Thompson* 1117
Irregularity among Cotton Plants in Time of Fruiting as a Factor Affecting Susceptibility to Damage by the Cotton Boll Weevil
*P. W. Calhoun* 1125
The Number of Larval Instars and the Approximate Length of the Larval Stadia of *Dendroctonus pseudotsugae* Hopk., with a Method for their Determination in Relation to Other Bark Beetles
*W. D. Bedard* 1128
The Resistance of Leaves of Red Clover to Puncturing
*H. H. Jewett* 1135
Fruit Injury on Apples Following Nicotine Tannate Sprays
*Byrley F. Driggers* 1137
Studies of the "Resistant" California Red Scale, *Aonidiella aurantii* Mask., in California
*Wallace Moore* 1140
The Mechanism of Absorption of Sodium Fluoride by Roaches
*George L. Hockenyos* 1162
Common Names of Insects Approved for General Use by American Association of Economic Entomologists 1169
Scientific Notes 1171
Proposals Regarding the Journal of Economic Entomology 1180
Editorial 1184
Obituary
Shinkai Isoshichi Kuwana 1185
Current Notes 1189
Horticultural Inspection Notes 1190

Forty-Sixth Annual Meeting of the

American Association of Economic Entomologists

Boston, Mass.

December 27 to 29th, 1933

# FORTY-SIXTH ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS, BOSTON, MASS.

*December 27 to 29th, 1933*

The 46th Annual Meeting of the American Association of Economic Entomologists will be held at Boston on the above dates. Sessions on Wednesday, December 27, will be held in the Hotel Bradford, which is also Hotel Headquarters. Sessions on Thursday and Friday, December 28 and 29th, will be held in Austin Hall, Harvard University, Cambridge.

The schedule of meetings has been arranged as follows:

Wednesday, December 27.
Section of Plant Quarantine and Inspection, sessions 1:30 P.M. and 7:30 P.M.
Section of Apiculture, session 1:30 P.M.
Section of Extension, session, 7:30 P.M.
Beekeepers Smoker, 7:30 P.M.

Thursday, December 28. Opening Session of General Association, 9:30 A.M.
Afternoon Sessions, 1:30 P.M.
Thursday Evening, the Entomologists Dinner.

Friday, December 29. General Session 9:30 A.M.
Afternoon, Symposium on the Spray Residue Problem, 1:30 P.M
Friday Evening. Final Business Session, 7:30 P.M.

## OTHER MEETINGS

The Annual Meeting of the American Association for the Advancement of Science, its sections and affiliated societies will be held December 27 to January 2.

The Entomological Society of America will open its meeting on Thursday morning, December 28, and continue through Friday, December 29. The annual public address before that society will be delivered by Dr. Frank E. Lutz of New York City on Thursday evening. Members of our Association are cordially invited to attend this session.

## HOTEL HEADQUARTERS

Hotel headquarters have been secured at the Hotel Bradford. The special convention rates are:

Room with bath, one person—$2.50, $3.00, $3.50, $4.00.
Room with bath, two persons—$3.50, $4.00, $4.50, $5.00 and $6.00.

## GARAGE—PARKING

Excellent parking and garage facilities are available near the Hotel Bradford. The Eliot Street Garage (heated) is one block from the hotel. Rates: $1.00 per night. There are several parking spaces within a block of the Hotel with rates of $.50 per night. At the Tremont and Broadway Space quotations have been offered of three days for $1.00, or $2.00 per week.

## RAILROAD RATES

Reduced railway rates by the certificate plan have been granted by almost all railroads in the United States and Canada. Persons attending the meeting should purchase a first class, one way ticket to Boston and secure a standard certificate form. The certificate must be validated in the registration office. The validated certificate allows continuous passage, return ticket for one-third of the regular fare by the same route before January 5, 1934. Tickets to Boston must be purchased between December 21 and December 23, both dates inclusive. Return tickets must be purchased by January 5.

Special fares have been announced by railroads in the Central and Trunk Line passenger associations. These tickets will be on sale December 14 to January 1 and will have a return limit of January 15, 1934. The rate of these special fares will be on round trip fare basis of one and one-ninth times the regular first class, one way fare. Consult local agents for most favorable rates.

## REGISTRATION

The Headquarters of the American Association for the Advancement of Science for registration and validation of certificates will be located in Memorial Hall, Harvard University. Fee for registration, validation, etc., will be $1.00.

## ENTOMOLOGISTS' DINNER

The Annual Entomologists' dinner will be held on Thursday evening, December 28, in the Hotel Bradford. Further notice of the place and hour will be given at the Wednesday and Thursday sessions.

## MEMBERSHIP

Applications for membership can be secured from the Secretary or from the Committee on Membership. These should be filled out,

properly endorsed and filed with the Membership Committee on or before December 28. Each application must be accompanied with a fee of $4.00.

## A. A. A. S. MEMBERSHIP

The American Association for the Advancement of Science is granting this year to members of affiliated societies, the privilege of joining that Association without the payment of the usual entrance fee.

Application cards are available through the Permanent Secretary of that Association.

## PROGRAM

*Wednesday Afternoon Session, December 27, 1:30 P.M. Hotel Bradford, Parlor A*

### Section of Plant Quarantine and Inspection

R. W. Leiby, *Chairman* S. B. Fracker, *Secretary*

Appointment of Committees on Resolutions and on Nominations.

Address by the Chairman, R. W. Leiby, Raleigh, N. C.

1. Developments in Pest Suppression in 1933. L. A. Strong, Washington, D. C.
2. Gipsy Moth Work East of the Barrier Zone and in Pennsylvania and New Jersey in 1933. A. F. Burgess, Greenfield, Mass.
3. Protection Given the Country by the Port Inspection Service. E. R. Sasscer, Washington, D. C.
4. Outbreak of an African Moth in Stored Senna. H. B. Weiss and E. G. Rex, Trenton, N. J.
5. The New Soil Disinfectant Employed in Potato Wart Eradication in Pennsylvania. R. E. Hartman, Hazleton, Pa.
6. Insect Findings of Recent Years Which are or May Become of Interest to Nursery Inspectors and Plant Quarantine Officers. J. A. Hyslop, Washington, D. C.
7. Developments in Bulb Pest Control with Special Reference to Lily Thrips, Gladiolus Thrips, and Narcissus Flies. C. A. Weigel, Washington, D. C.
8. The Tomato Pinworm in Eastern Pennsylvania. T. L. Guyton, Harrisburg, Pa.

## Program

*Wednesday Evening Session, December 27, 7:30 P.M. Hotel Bradford, Parlor A*

9. The European Earwig as a Pest in Rhode Island. A. E. Stene, Providence, R. I.

10. The New Outbreak of the Dutch Elm Disease. R. Kent Beattie, Washington, D. C.

11. Vapor-Heat Treatment and Other New Methods of Disinfecting Plant Materials. L. A. Hawkins, Washington, D. C.

12. Plant Quarantine Legislation Supported by Numerous Court Decisions. S. B. Fracker, Washington, D. C.

13. Prevention of Spread of the European Pine Shoot Moth. A Committee Report. H. L. McIntyre, Albany, N. Y.

14. Additional Inspection of Nurseries on Account of European Pine Shoot Moth. W. E. Britton, New Haven, Conn.

15. Some Peculiarities of State Regulations Concerning the Movement of Nursery Stock and Comments. A. G. Ruggles, St. Paul, Minnesota.

16. Report of the National Plant Board. W. C. O'Kane, Chairman, Durham, N. H.

17. Reports of the Regional Boards:

The Eastern Plant Board. E. N. Cory, Secretary, College Park, Md.

The Central Plant Board. P. T. Ulman, Secretary, Indianapolis, Ind.

The Southern Plant Board. J. H. Montgomery, Secretary, Gainesville, Florida.

The Western Plant Quarantine Board. A. C. Fleury, Secretary-Treasurer, Sacramento, Calif.

Report of Resolutions Committee.

Report of Nominating Committee.

Selection of Officers.

Adjournment.

## Program

*Wednesday Afternoon Session, December 27, 1:30 P.M. Hotel Bradford, Parlor B*

SECTION OF APICULTURE

W. E. BRITTON, *Chairman* W. E. DUNHAM, *Secretary*

Appointment of Committees on Resolutions and on Nominations.

Address by the Chairman, W. E. Britton, New Haven, Conn. "Miscellaneous Problems in Beekeeping."

1. Broodrearing in the Honeybee Colony. J. A. Munro, Fargo, N. D.

Results of brood measurements conducted on package and overwintered colonies of bees.

2. Adult Bees Dying on Spotted Loco. George H. Vansell and William Watkins, Davis, California.

Report of search for cause of "Nevada Bee Disease" with the finding of honey bees dying on the above plant.

3. Spray Poison in the Yakima Valley. R. L. Webster and Arthur Crews, Pullman, Washington.

The use of arsenate of lead in large quantity for the control of the Colorado beetles in the Yakima Valley, Washington, in 1933 resulted in extremely heavy losses to colonies of commercial beekeepers and the smallest honey crop in the history of commercial beekeepers.

4. Planning an Extension Project in Beekeeping. E. J. Anderson, State College, Pa.

5. Studies in the Physical Characteristics of some Massachusetts Honey Bees. C. R. Kellogg, Amherst, Mass.

6. Studies on European Foulbrood and Parafoulbrood. C. E. Burnside, Bureau of Entomology, U. S. Department of Agriculture, Washington, D. C.

Two theories exist regarding the etiology of European foulbrood of bees; namely, (1) That this decrease is caused by *Bacillus pluton* and that *Bacillus alvei*, *Streptococcus apis*, and *Bacterium eurydice* are distinct species constantly associated with European foulbrood as secondary invaders, and (2) That *B. pluton* is a stage in the life history of *B. alvei*. Results of experiments seem to indicate that *B. alvei* is an unstable organism capable of growing as a sporogenic rod, or as a coccoid. Results also indicate that parafoulbrood is caused by *Bacillus para-alvei*, a recently discovered bacterium which appears related to *B. alvei* and likewise is capable of growing as a rod or a coccoid. By special culture methods cultures of *B. alvei* which sporated promptly on nutrient agar were modified so that no spores were produced when cultured on the same mediums.

Cultures of a coccoid isolated from larvae sick of European foulbrood occasionally gave rise, after several generations, to rods and spores of *B. alvei*. By similar culture methods *B. para-alvei* was changed from sporogenic to asporogenic rods. Cultures of a coccoid isolated from larvae sick of parafoulbrood occasionally gave rise to rods and spores of *B. para-alvei*. Sporogenic cultures of *B. para-alvei* gave rise to two coccoid types. One of these was indistinguishable morphologically from cultures which were isolated from larvae sick of parafoulbrood. *Bacillus para-alvei* is described.

7. A Preliminary Report on the Feasibility of Treating Colonies Affected with American Foulbrood (*Bacillus larvae*). W. E. Dunham and P. E. King, Columbus, Ohio.

The results of investigations covering two seasons are given on treating colonies of honey bees affected with American foulbrood together with a bacteriological verification.

8. Some Aspects of Apiculture in the Past and Future. Prof. Herbert Osborn, Columbus, Ohio.

A brief reference to some of the early American workers in apiculture. The lives of investigators that have been followed with suggestions of possible phases in research desirable in the future.

9. Biometrical Studies on *Apis florea* F. Claude R. Kellogg, Amherst, Mass.

Biometrical measurements were made upon preserved specimens of *Apis florea* Fabr., from South India with the aid of a micrometer eye-piece. The body length, submentum, mentum, length of right forewing, width of right forewing, and number of hooks on the right hind wing all showed variation in individual bees, but the means of these measurements are so constant that they may be used in the determination of the species.

10. The Variation in Weight per Gallon of Honeys from Different Floral Sources. George E. Marvin, Bureau of Entomology, U. S. Department of Agriculture, Washington, D. C.

The weight per gallon of 40 honeys of various floral sources obtained from different parts of the country was determined by direct weighing and by the refractometer. A considerable variation was found in the weight of these honeys. This variation applied not only to honeys of different floral sources, but also to honeys of the same floral source but from different localities and even in some cases to honeys of the same locality. Honeys produced in regions of high humidity weighed less than those from dry, irrigated sections.

The weight of the 40 honeys varied from 11.69 to 11.99 pounds per gallon. By direct weighing, not one sample weighed as much as 12 pounds per gallon, the figure which up to this time has been considered the minimum weight per gallon for a well-ripened honey. This study of 40 samples substantiates the decision, based on experiments covering a longer period, to place the minimum weight specification in the U. S. Grades for honey at 11.75 pounds per gallon of 231 cubic inches.

11. The Relation Between Number of Ovarioles and Size in Queen Honey Bee. J. E. Eckert, Davis, Calif.

12. The Use of Thermocouples in the Determination of Relative Humidity. A. W. Woodrow, Ithaca, N. Y.

Difficulty is often encountered in biological work in the measurement of relative humidity in small containers. A method is described which may be used when ordinary methods of meteorology are inconvenient or unsatisfactory.

13. The Effect of Colony Size on the Flight Rates of Bees. A. W. Woodrow, Ithaca, N. Y.

This is an account of further work on the previously reported subject of the comparative value of different colonies of bees in fruit pollination. Information obtained during the pollination seasons of 1932 and 1933 is included.

Report of Committees.

Selection of Officers.

Adjournment.

## Program

*Wednesday Evening Session, December 27, 7:30 P.M. Hotel Bradford, Parlor C*

### Section of Extension

H. E. Hodgkiss, *Chairman* M. P. Jones, *Secretary*

Symposium: Dissemination of Entomological Information.

1. Problems of the Extension Entomologist. H. E. Hodgkiss, State College, Pa.

2. Methods of Conducting Extension Work. C. R. Crosby, Ithaca, N. Y.

3. Extension Activities in the Entomological Program for Delaware. L. A. Stearns, Newark, Delaware.

4. Aims and Purposes of Extension Entomology. A. B. Graham, Washington, D. C.

5. Discussion of Papers.

6. Why Insect Control Practices Fail. Extension Entomologists, State College, Pa.

7. Popularizing Entomology. Bristow Adams, Ithaca, N. Y.

8. Procedures Responsible for Minnesota's Successful Grasshopper Control Campaign. T. L. Aamodt, St. Paul, Minnesota.

Selection of Officers.

Adjournment.

## Program

*Thursday Morning Session, December 28, 9:30 A.M. Austin Hall, Harvard University, Middle Hall*

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Report of the Secretary.

Report of the Executive Committee by President W. E. Hinds.

Report of the Representative to the National Research Council, by W. A. Riley, St. Paul, Minn.

Report of the Governors of the Crop Protection Institute, by W. C. O'Kane, Durham, N. H.

Report of Scientific Trustee, Tropical Plant Research Foundation, by Herbert Osborn, Columbus, Ohio.

Report of the Representative on the Council of the Union of Biological Societies, by C. R. Crosby, Ithaca, N. Y.

Report of the Committee on Nomenclature, by J. A. Hyslop, Washington, D. C.

Report of the Committee on Endowment, by V. I. Safro, West Nyack, N. Y.

Report of the Board of Trustees for Permanent Fund, by A. I. Bourne, Amherst, Mass.

Report of the Committee on Insect Collections, by J. J. Davis, Lafayette, Indiana.

Report of the Committee to Formulate Plans for Investigation of the Codling Moth from Biologic and Control Standpoints, by B. A. Porter, Washington, D. C.

Report of the Committee on Research Work on the Control of the European Corn Borer, by G. A. Dean, Manhattan, Kansas.

Report of the Committee on Training of Entomologists, by C. J. Drake, Ames, Iowa.

Report of the Sub-committee on Entomological Exhibits for the Chicago Century of Progress Exposition, by W. P. Flint, Urbana, Illinois.

Report of Special Committee on Policy of the Journal of Economic Entomology, by H. J. Quayle, Riverside, California.

Report of Special Committee on Joint Meeting with the Entomological Society of America in Chicago, by W. P. Flint, Urbana, Illinois.

Report of Special Committee for Investigation of Reorganization of Entomological Research in the Federal Government, by E. F. Phillips, Ithaca, N. Y.

Appointment of Committees.

Miscellaneous Business.

New Business.

Annual Address of the President, W. E. Hinds, Baton Rouge, La.

1. Some Achievements in Economic Entomology.

## Program

*Thursday Afternoon Session, December 28, 1:30 P.M. Austin Hall, Harvard University, Middle Hall*

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

*Reading of Papers*

2. What Shall be the Objective in the Training of an Entomologist. (5 min.) Dwight M. DeLong, Columbus, Ohio. (Lantern).

3. Some Queries Concerning Research Methods and Equipment. (5 min.) (Lantern). Alvah Peterson, Columbus, Ohio.

Some preliminary studies of materials used in constructing apparatus, etc.

4. On the Hereditary Ability of Certain Insects to Transmit Diseases and Diseaselike Injuries of Plants. (5 min.) (Lantern) F. W. Poos and Nancy H. Wheeler, Rosslyn, Virginia.

Discusses the disease-like injury caused by *Empoasca fabae* (Harris) and the blight of spinach transmitted by aphids.

5. Probable Effect of Regulated Production on Insect Abundance on Corn. (5 min.) J. H. Bigger, Jacksonville, Ill.

Studies of the effect of rotations on insect abundance in corn for the past five years have shown that where a rapid rotation is carried out and where the corn crop is immediately preceded by a legume from 53.2 to 80.5% of the corn will be free from insect damage by those insects which attack the underground portion of the plant.

6. The Chemical Constants of the Fats of Hibernating *Carpocapsa pomonella* and *Leptinotarsa decemlineata*. (5 min.) (Lantern). David E. Fink, Takoma Park, Md.

The paper deals with the chemical constants of the fats, of the saturated and unsaturated fatty acids, and of the soluble and insoluble acids of the fats determined every other week during the period of hibernation.

7. Observations on the Recent Outbreak of Encephalitis in Columbia, Missouri and a Study of the Possible Insect Carriers. (5 min.) Leonard Haseman, Columbia, Missouri.

Includes a brief history of each case and condition surrounding each, their distribution in the city together with a report on the possible insect carriers which were most prominent before and during the outbreak.

8. Preliminary Studies on Biological Control of *Pseudococcus brevipes* (Ckl.) (5 min.) Walter Carter, Honolulu, Hawaii.

Observations made in Jamaica and Central America reveal an extreme paucity of parasitism of *P. brevipes* and other species of mealy bugs on pineapple. Predator complexes offer some promise but are limited on account of minimum host-population requirements. Factors involved in biological control of disease-transmitting insects in general and of *P. brevipes* in particular are considered.

9. Technique Employed in Distributing *Thripoctenus brui* Vuillet in the Hawaiian Islands. (5 min.) Carl T. Schmidt, Honolulu, Hawaii.

A description is given of methods of reception and handling of the parasite, *Thripoctenus brui* Vuillet, introduced to the Hawaiian Islands for the purpose of controlling the onion thrips, *Thrips tabaci* Lind., the insect vector of "Yellow-spot" a virus disease of pineapple.

10. Hallucinations of Insects Causing Annoyance to Man. (5 min.) Roger C. Smith, Manhattan, Kansas.

A brief account of two cases of hallucination of insect attack with a discussion of the relation of memory, suggestion and certain drugs to this problem.

**Insects Affecting Field, Cereal and Forage Crops**

11. The Green June Beetle in Lawns. (5 min.) W. A. Price, Lexington, Kentucky.

Method used to clear the lawn of grubs.

12. Strains of Corn Resistant to the European Corn Borer. (5 min.) (Lantern). L. H. Patch, Toledo, Ohio.

One resistant inbred strain of corn transmits characters to the hybrids in which it enters, inhibiting the survival of about one-half the number of corn borers that would normally survive on the susceptible varieties and hybrids of corn.

13. The European Corn Borer in Connecticut During 1933. (5 min) (Lantern). J. Peter Johnson, New Haven, Conn.

An account of the commercial damage to sweet and seed corn as obtained in the field and from growers together with a summary of the annual fall borer population survey.

14. The History of the European Corn Borer (*Pyrausta nubilalis* Hubn.) on Long Island, New York. (5 min.) (Lantern). S. M. Dohanian, Arlington, Mass.

A brief history and the present status of the European Corn Borer on Long Island, N. Y. are presented.

15. Experimental Results Obtained in the Use of Ammonium Sulphosoap with Nicotine Insecticides Against the European Corn-borer.

(5 min.) (Lantern). C. H. Batchelder and D. D. Questel, Arlington, Mass.

Nicotine insecticides with ammonium sulpho soap as a surface-tension depressant were used on dahlia and corn infested by the European corn-borer.

16. Comparative Effectiveness of Stalk-harvesting Methods in the 2-Generation Area of European Corn-borer Infestation. (5 min.) (Lantern). C. H. Batchelder and D. D. Questel.

Results of 1933 experiment plot tests of silage harvesting methods in relation to infestation of corn by the European corn-borer.

17. Subfreezing Temperatures Lethal to the European Corn-borer Infesting Green Ears of Sweet-corn. (5 min.) (Lantern). C. H. Batchelder and D. D. Questel, Arlington, Mass.

Methods of freezing green sweet-corn found necessary to insure safety from spread of the European corn-borer into uninfested territory.

18. Additional Results on the Reactions of Corn Earworm Moths to Several Sugars. (5 min.) (Lantern). L. P. Ditman and R. A. Littleford, College Park, Md.

Results of experiments to determine the relative attractiveness of sucrose, fructose and invert sugar to corn earworm moths.

19. Recent Additions to Our Knowledge of the Life History of the Pea Weevil. (5 min.) A. O. Larson, T. A. Brindley, Frank G. Hinman, Corvallis, Oregon.

New information has been obtained in regard to the method of hibernation quarters. Some adult pea weevils live more than one year. The weevils may oviposit the same summer that they develop or over a period of at least two more summers. One weevil may lay more than 700 eggs. Feeding punctures made by adult pea weevils may cause deformed pods in some varieties of peas.

20. Barium Fluosilicate in Blister Beetle and Cabbage Worm Control. (5 min.). H. F. Dietz and E. E. Zeisert, Wooster, Ohio.

Three years experiments with barium fluosilicate (Dutox) dusts show that this material meets the requirements of an effective, inexpensive control for blister beetles on vegetable and ornamental plants. Where standard arsenical sprays and dusts failed to control heavy infestations of cabbage worms, during the past season, barium fluosilicate dusts were very effective.

21. Seed Treatments for the Control of Root Maggots. (5 min.) (Lantern). Hugh Glasgow, Geneva, N. Y.

This paper discusses the effects of certain insecticides applied to the seed in preventing root maggot injury.

22. Ground Derris Root for Control of Cabbage Maggot. (5 min.) Robert C. Burdette, New Brunswick, N. J.

23. Field Studies of *Thrips tabaci* Lind. with Especial Reference to Resistance in Onions. (5 min.). Stanley F. Bailey, Davis, Calif.

Field studies of the onion thrips which establish the significant resistance of the White Persian variety.

24. Recent Experiments in the Control of the Onion Thrips. (5 min.) (Lantern). J. P. Sleesman, Ada, Ohio.

25. A Progress Report on the Control of the Potato Psyllid *Paratrioza cockerelli* Sulc. and Psyllid Yellows Caused by Its Feeding. ( 5 min.) George M. List and Leslie B. Daniels, Fort Collins, Colorado.

"Psylled Yellows" which is one of the most important potato problems in the West has a definite response to the use of certain spray materials.

26. Further Investigations Regarding the Morbid Histology of "Psyllid Yellows". (5 min.) (Lantern). J. R. Eyer, State College, New Mexico.

Further studies of the histology of the normal potato plant as compared with that of plants affected with "Psyllid Yellows" corroborated the findings of past seasons and showed conclusively that the psyllid nymphs, when feeding normally on the leaves in the field, extract their nourishment largely from the border parenchyma surrounding the vacular bundles. This feeding apparently interferes with translocation at inception and typical chlorotic symptoms follow. No necrosis of any of the tissues other than those at the point of actual feeding was observed. Furthermore, there is no wholesale destruction or mechanical plugging of the vacular tissues. Microchemical studies of the stylet sheath (e.g. the path which the beak traverses in its entrance into the plant tissues) showed that it is largely intercellular although occasionally the stylets pierce individual cells while being forced into the parenchyma. Pectic materials in the cell walls are dissolved, mucin occurs in the stylet sheath, but no extensive suberization or cutinization results in the tissues where feeding occurs. Cells having been penetrated by the beak collapse and become filled with disintegrated granular protoplasm. A comparison of healthy and diseased petiole and stem tissues showed that there are significant differences in the synthesis of starch in plants affected with "Psyllid Yellows." Abnormally heavy starch deposits occur in the cortex and pith while starch is almost invariably absent in the endodermis and starch sheath where it normally occurs in the stems and petioles of healthy plants.

27. The Effect of Alfalfa Cutting Schedules Upon the Occurrence of Alfalfa Leafhoppers and Alfalfa Yellows in Wisconsin. (5 min.) E. M. Searles, Madison, Wisconsin.

28. The Use of Oil in Grasshopper Baits. (5 min.) J. R. Parker, R. L. Shotwell and F. A. Morton, Bozeman, Montana.

29. Injury to Heads of Grasses by Grasshoppers. (5 min.) Donald A. Wilbur, Manhattan, Kansas.

30. Result of Three Years Work Against Grasshoppers in Minnesota. (5 min.) A. G. Ruggles, St. Paul, Minn.

31. Observations on the Seasonal Activities of Wire Worms (Elateridae). (5 min.) Harry R. Bryson, Manhattan, Kansas.

Results of observations made on the seasonal activities of wireworms at Manhattan, Kansas in connection with field studies, rearings, and ecological studies.

32. The Importance and Distribution of Phyllophaga spp. in Wisconsin During 1933. (5 min.) P. O. Ritcher and C. L. Fluke, Madison, Wisc.

Flight of Brood "B" small but widespread. Twelve of the twenty-one species of June beetles known to occur in Wisconsin collected this year on food plants, at baits, and at lights. Grub damage by broods "A" and "C" severe, many pastures totally ruined.

33. Subterranean Movements of White Grubs in Wisconsin and Their Relation to Farm Practices. (5 min.). C. L. Fluke and P. O. Ritcher, Madison, Wisconsin.

Weekly diggings of white grubs indicate errors in past recommendations for grub control by farm practices.

34. Life History and Control of the Potato Flea-Beetle *Epitrix cucumeris* Harris, in Eastern Virginia. (5 min.) (Lantern). Lauren D. Anderson, Norfolk, Virginia.

The Potato Flea-Beetle, *Epitrix cucumeris* Harris, is a problem of outstanding importance to Irish potato growers of Eastern Virginia. The adults feed on the foliage from its first appearance until the vines are dead, causing a premature dying of plants and reduction in yield. At the same time the larvae feed upon the tubers causing a rough, pitted potato of inferior quality. Thirty different materials were used in the control project, the better materials giving an increase of 88 bushels of U. S. No. 1 potatoes per acre over the checks.

35. Studies of Millipeds and Gnat Injuries to Potato Tubers. (5 min.) (Lantern). G. F. MacLeod and F. G. Butcher, Ithaca, N. Y.

Results of experiments with sulphur and naphthalene for the control of millipeds and gnats on potatoes.

36. Experimental Studies of the Wheat Wireworm, *Agriotes mancus* Say. (5 min.) (Lantern). W. A. Rawlins, Ithaca, N. Y.

Ecological studies for the control of wireworms.

37. The Use of Naphthalene for the Control of Onion Thrips. (5 min.) (Lantern). F. B. Maughan, Ithaca, N. Y.

Results obtained using naphthalene alone and in combination with dust carriers.

38. Potato Spraying and Dusting Experiments on Long Island. (5 min.) (Lantern). Henry Menusan, Ithaca, N. Y.

Decreases in yields of potatoes obtained with Bordeaux sprays.

39. The Effects of Potato Sprays on Larval Feeding of Flea Beetles on Tubers. (5 min.) (Lantern). D. O. Wolfenbarger, Ithaca, N. Y.

Variable results showing little or no correlation between spraying practices and larval potato flea beetles.

40. Chinch Bug Resistance in Corn—An Inherited Factor. (5 min.) (Lantern). J. R. Holbert and W. P. Flint, Urbana, Ill.

During the past year work carried on at Bloomington, Illinois with a number of inbred strains of corn and crosses of such corns has shown very conclusively that certain strains carried chinch bug resistance, or susceptibility to chinch bug injury as a dominant factor. It has also been shown that certain other strains which are either resistant or susceptible in themselves do not carry such qualities as dominant inherited factors. Further data are also presented showing the degree of susceptibility or resistance in certain varieties of corn adapted to the central and north central parts of the corn belt.

## Program

*Thursday Afternoon Session, December 28, 1:30 P. M. Austin Hall, Harvard University, West Hall*

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

*Reading of Papers*

41. Dutch Elm Disease Control and the Elm Bark Borer. (5 min.) E. P. Felt, Stamford, Conn.

The recognition of the European elm bark beetle as an important and possibly the principal carrier of the Dutch elm disease and present conditions make the control of this insect a problem of major importance. The discovery of imported elm logs infected with the disease and infested with this beetle goes far to establish the origin of the American infections. The elm bark beetle is restricted in its breeding largely to sickly and dying wood, and since it is the presumably important carrier of the disease, it is desirable to reduce the breeding of this insect. The systematic cutting out and burning of sickly or dying trees or parts of trees is a practical measure, since general tree sanitation produces conditions unfavorable to this Dutch elm disease carrier. It is also good tree practice and can be recommended for communities distant from any known infection. Repeated defoliations by insects justify a comprehensive spray program in order to maintain tree vigor and lessen the amount of sickly and dying wood. Weak trees should either be summarily removed or treated to restore vigor. The threat of the Dutch elm disease abundantly justifies a policy of control and possible eradication.

42. Exploring Upper Air for Wind-borne Gipsy Moth Larvae. (5 min.) (Lantern). C. W. Collins and W. L. Baker, Melrose Highlands.

43. Notes on the Beech Scale (*Cryptococcus fagi* Baer.) in New England. (5 min.). (Lantern). R. C. Brown, Melrose Highlands, Mass.

44. Control of the European Pine Shoot Moth by Spraying. (5 min.) (Lantern). R. B. Friend and A. S. West, Jr., New Haven, Conn.

A lead arsenate fish oil mixture has given excellent results.

45. The Control of the Willow Snout Beetle (*Orchestes rufipes*) in Maine. (5 min.) H. B. Peirson and Robley W. Nash, Augusta, Maine.

46. Some Observations on the Fir Bark Louse (*Dreyfusia picea* Ratz.) in Maine. (5 min.) (Lantern). H. B. Peirson and Arthur M. Gillespie, Bar Harbor, Maine.

47. Predatory Checks, Especially Birds, on the Birch Leaf-mining Sawfly, *Phyllotoma nemorata* Fall. (5 min.) (Lantern). A. E. Brower, Bar Harbor, Maine.

When this European insect became epidemic in Maine, the percentage of destruction by birds was found to be small, but it has constantly increased. Birds have not been found destroying the native leaf-miners.

48. A New Mite on Boxwood (*Neotetranychus buxi* n. Sp. Garman). (5 min.) (Lantern). Donald T. Ries, Bloomfield Hills, Mich.

A biological study of mite as recorded in Oakland County, Michigan.

49. Insect Work in Civilian Conservation Corps Camps in Connecticut. Control Measures Taken Against White Pine Weevil and European Pine Shoot Moth. (5 min.) George H. Plumb and Henry W. Hicock, New Haven, Conn.

**Insects Affecting Deciduous Fruits**

50. Codling Moth Activity as Indicated by Phototropic Response. (5 min.) (Lantern). P. J. Parrott and Donald L. Collins, Geneva, N. Y.

Seasonal history of codling moth as shown by captures at lights compared with records from emergence cages and with captures in bait pails. Records relative to flights of stained moths.

51. Occurrence of *Ascogaster carpocapsae* in Illuminated and Sprayed Areas of an Apple Orchard. (5 min.) (Lantern). P. J. Parrott and Donald L. Collins, Geneva, New York.

The occurrence of cocoons and adults of *A. carpocapsae* in relation to the host population in differently treated areas of an apple orchard.

52. Further Results With Codling Moth Bands in Pennsylvania. (5 min.) (Lantern). Harlan N. Worthley, State College, Pa.

Attractiveness and killing power of different types of band. Data on cost and effectiveness of banding operation.

53. Some Results Secured with Supplementary Control Measures for the Codling Moth. (5 min.) Leonard Haseman and George D. Jones, Columbia, Missouri.

Results secured where codling moth populations were very high by using light and heavy spray schedules both with and without supplementary control measures.

54. The Apple Leaf-Curling Midge, A New Pest of Apples. (5 min.) (Lantern). W. D. Whitcomb, Waltham, Mass.

*Dasyneura mali* Kieffer, which rolls the leaves of terminal shoots and water sprouts on apple, is now well established in northeastern Massachusetts and southeastern New Hampshire and its distribution, habits, life history, as well as the injury which it causes are discussed.

55. Notes on Control of the White Apple Leafhopper in Connecticut. (5 min.) (Lantern). Philip Garman, New Haven, Conn.

Summary of field control work with this insect since 1931 at the Conn. Agric. Exp. Station.

56. Some Observations on Long Distance Dispersal of Apple Maggot Flies. (5 min.) (Lantern). A. I. Bourne, Amherst, Mass.

Attempts to discover the limits of probable dispersal of Apple Maggot flies, by releasing marked flies at distances of 400 to 600 yards from bearing trees.

57. Sixth Contribution to a Study of Baits With Special Reference to Oriental Fruit Moth. (5 min.) G. W. Frost, Arendtsville, Pa.

Tests with numerous chemicals are summarized. Special emphasis is placed on other insects which are attracted by baits and interfere with the effectiveness of the baits.

58. Methods of Determining the Degree of Parasitism of Twig-Infesting Oriental Fruit Moth Larvae. (5 min.) H. G. Butler, Harriman, Tenn.

A brief discussion of the three methods used in 1930 and 1931, 1932, and 1933 respectively. A comparison of data so taken in 1933 as to permit assembling in two ways, shows that a difference of 8 per cent, 20 per cent and 25 per cent in the degrees of parasitism, as determined by the two methods, exists in the records of June, July and August respectively. The results of a single, separate, different test of the basic idea show a difference of 22 per cent in the degree of parasitism found in larvae collected at the same tine in the same orchard. The method used, while both logical and simple, is not known to the writer to have been previously reported.

59. Results of Further Experiments With a New Method for the Control of the Peach Borer, *Aegeria exitiosa*, with Special Application to Nursery Stock. (5 min.) (Lantern). Oliver I. Snapp, Fort Valley, Georgia.

This paper gives the results of experiments with emulsions of oils impregnated with para-dichlorobenzene and applied as sprays for the control of the peach

borer. The method is the only safe and effective one known for the control of the insect in nursery stock and young peach trees.

60. A Progress Report on the Control of the Cherry Case Bearer (*Coleophora pruniella* Clem.) in Wisconsin. (5 min.) J. H. Lilly and Charles L. Fluke, Jr. Madison, Wisconsin.

The various materials used are compared as to insect kill and tree injuries. The importance of concentrations used, value of certain supplementary materials, relation of temperature and time of application to effectiveness, and the importance of thorough spraying are also discussed.

61. Observations on the Habits and Control of *Glossonotus crataegi* (Membracidae), on Plum and Apple. (5 min.) Ray Hutson, East Lansing, Mich.

62. "*Phylloxera devastatrix* Perg. on Pecans". An Account of the Seasonal History, Habits, and Methods of Control of *P. devastatrix* on Pecans is Given. (5 min.) Howard Baker, Marshfield, Mass.

63. Experiments with Kerosene Against the Apple Curculio. (5 min.) (Lantern). Oscar H. Hammer, Geneva, N. Y.

The effect of various strengths of kerosene emulsions on the hibernating and immature forms of the apple curculio are discussed.

## Program

*Friday Morning Session, December 29, 9:30 A. M. Austin Hall, Harvard University, Middle Hall*

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

*Reading of Papers*

### Insecticides

64. Foliage Injury Caused by Arsenicals and Bordeaux Mixture. (5 min.) S. F. Potts, Melrose Highlands, Mass.

65. Dairy Fly Sprays. (5 min.) (Lantern). Stanley B. Freeborn, Davis, California.

A resume of eight years' work including new data on their efficiency and effect on the dairy cow.

66. The Relative Value of Bordeaux, Sulphur and Pyrethrum Products in Reducing Populations of Potato Leafhopper. (5 min.) (Lantern). Dwight M. DeLong, Columbus, Ohio.

Graphs will be shown to indicate the natural populations in the field and the type and percentage of reduction in populations obtained by these materials. The "residual" value of Bordeaux and sulphur is shown.

67. Pyrethrum Dusts on Cranberry Bogs. (5 min.) (Lantern). E. Avery Richmond, Brockton, Mass.

A general review of results obtained by the use of pyrethrum dust mixtures for the control of cranberry insects, occurring on the bogs of southeastern Massachusetts, during 1931–1933 inclusive.

68. Preliminary Report on the Insecticidal Action Against Thrips of Derris, Nicotine, Paris Green and Other Poisons in Combination with Molasses. (5 min.) (Lantern). H. H. Richardson, Washington, D. C.

Laboratory and greenhouse studies on the toxicity toward thrips of nicotine sulphate, derris extract, hellebore, pyrethrum, Paris green and other insect poisons in combination with molasses are reported. The importance of a toxic and stable spray deposit in contrast to strong contact action for thrips control is discussed. Tests on the stability to sunlight of the deposits left by various derris sprays are also reported.

69. Notes on the Use of Derris and Pyrethrum Dusts for the Control of Certain Insects Attacking Cruciferous Crops. (5 min.) (Lantern). Harry G. Walker and L. D. Anderson, Norfolk, Virginia.

This is a report on the use of different strengths of Derris and Pyrethrum dusts for the control of the cabbage looper *Autographa brassicae* Riley, the larvae of the diamond backed moth *Plutella maculipennis* Curt., and the Harlequin bug *Murgantia histrionica* Hahn. The results obtained with Derris dust used in combination with the following inert carriers, gypsum, talc, lime, flour, clay, tobacco dust, and a zinc sulphate-lime mixture for the control of these three insects are also given.

70. Insecticidal Properties of Completely Extracted Derris Root Residue. (5 min.) Lantern). Joseph M. Ginsburg and Philip Granett, New Brunswick, N. J.

Residues from derris root extracted with acetone possess toxicity and repellency to cabbage worms and silk moth caterpillars, but no toxicity to aphis. Residue from derris root extracted first with acetone and then with water has shown no direct toxicity to chewing insects but still possessed strong repellent and deterrent properties.

71. Recent Developments in Oil Sprays. (5 min.) Hugh Knight and C. R. Cleveland, Claremont, California and Chicago, Illinois.

Internal oil soluble emulsifiers comprising certain glycerides of the fatty acids, not only give excellent emulsions for spraying purposes, but also change the physical characteristics of petroleum oil so as to retard penetration into plant tissue and maintain surface films for greatly extended periods of time. These can be regulated by varying the proportions of the oil soluble emulsifier. By the use of these materials there are indications that the field of usefulness of oil sprays may be greatly extended so as to include a materially improved control of Codling Moth and allied insect pests. Examples of some preliminary

field tests against scale infesting citrus, codling moth on apples, and pear psylla, on pears, are given.

72. Further Studies on the Oil-Depositing Property of Oil Sprays. (5 min.) R. H. Smith and J. P. LaDue, Riverside, Calif.

73. The Synergistic Effect of the Chlorides and Bicarbonides of Potassium and Sodium, upon the Paralytic Action of Nicotine in the Cockroach. (5 min.) N. D. Levine and C. H. Richardson, Ames, Iowa.

74. Halowax As a Contact Insecticide. (5 min.) E. P. Breakey, Columbus, Ohio.

A summary of studies relative to the use of Halowax, a chlorinated naphthalene product, as a contact insecticide.

75. Role of Some Southern Pine Products in Control of *Aphis rumicis*. (5 min.) C. O. Eddy, Lexington, Ky.

76. Notes on Paradichlorobenzene, Naphthalene and the Cedar Oils as Repellents Against Clothes Moth Adults. (5 min.) (Lantern). Samuel C. Billings, Silver Spring, Md.

Adult clothes moths freely laid their eggs on pieces of flannel that had been placed in the vapors of the various substances listed in the title. The resulting larvae fed freely. Pictures of the five pieces of flannel will be shown in the lantern. The purpose of this article is to establish that these materials are not clothes moth repellents.

77. A New Non-inflammable, Non-explosive Fumigant. (5 min.) R. M. Jones, Mountain Grove, Missouri.

78. A Review of Pyrethrum as an Agricultural Insecticide. (5 min.) Alfred Weed and M. D. Leonard, New York, N. Y.

A brief resume of the history, development and present uses of pyrethrum for the control of insects injurious to plants. Suggestions are made for future lines of work and references to the more important sources of information are cited.

79. Some Effects of the Vapor of Ethylene Oxide on the Bean Weevil and the Confused Flour Beetle. (5 min.) (Lantern). William R. Horsfall, Monticello, Arkansas.

With concentrations of the gas below that causing death and with very short exposures several parts of the different stages were found to be affected.

**Spray Residue and Lead Arsenate Substitutes**

80. Some Results Secured with Supplementary Control Measures for the Codling Moth. (5 min.) Leonard Haseman and George D. Jones, Columbia, Missouri.

Results secured where codling moth populations were very high by using light and heavy spray schedules both with and without supplementary control measures.

81. Arsenic Deposit and Codling Moth Control. (5 min.) (Lantern) R. L. Webster, Pullman, Wash.

High deposits of lead arsenate have been necessary to check the codling moth in the Pacific Northwest. Deposits have been increased by the use of fish oil, mineral oil, and colloidal spreader. Difficulty in residue removal has occurred following certain combination sprays.

82. Effects on Apple Foliage of Different Arsenicals and Fungicides in Combination. (5 min.) (Lantern) C. R. Cutright, Wooster, Ohio.

Five arsenicals and five fungicides were used in 25 combinations to determine their various effects on apple foliage. As the experiment progressed defoliation seemed to be the outstanding feature in the performance of certain of the combinations and a special method of taking such records was developed. A brief description of this method together with the data so collected is presented.

83. Some Comparisons Between Calcium Arsenate and Lead Arsenate as General Insecticides of Apple. (5 min.) (Lantern) P. J. Chapman, G. W. Pearce, R. W. Dean and O. H. Hammer, Geneva, N. Y.

Field and laboratory data are given on differences found among several commercial calcium arsenates and on the behavior of this material in various combinations as regards safety to the host and toxicity to the more important apple pests.

84. Comparative Tests of Arsenicals, Arsenicals with Oil and Several Nicotine Compounds Used Against the Codling Moth. (5 min.) (Lantern) Byrley F. Driggers, New Brunswick, N. J.

85. Lead Arsenate Substitutes for Codling Moth Control. (5 min.) James Marshall, Wenatchee, Washington.

Calcium arsenate, manganese arsenate, zinc arsenate, and zinc arsenate applied in combination with animal, vegetable, and mineral oils have resulted in widely varying degrees of codling moth control and foliage and fruit injury following tests in the Wenatchee Valley, Washington. Certain combinations of these materials have given results comparable to lead arsenate used alone

## Program

*Friday Afternoon Session, December 29, 1:30 P. M. Austin Hall, Harvard University, Middle Hall*

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

**Symposium on the Spray Residue Problem**

Discussion Under the Direction of P. J. Parrott, Geneva, N. Y.

Control of Interstate Traffic in Sprayed Fruits and Vegetables during the Current Season, by W. B. White of the Food and Drug Administration, Washington, D. C.

The Status of Codling Moth Control with Insecticides. R. L. Webster (12 min.)

Three Minute Discussions of Regional Aspects of the Problem

E. J. Newcomer
W. P. Flint
S. W. Harman
W. S. Hough

To What Extent May Organic Insecticides be Used as Substitutes for Arsenicals. T. J. Headlee (12 min.)

The Situation in the Vegetable Industry with Respect to the Use of Arsenicals and Arsenical Substitutes. W. H. White (12 min.) H. C. Huckett (12 min.)

Latest Developments in Spray Residue Removal. H. C. Robinson (12 min.) H. C. McLean and Albert Weber (12 min.)

## Program

*Friday Evening Session, December 29, 7:30 P. M. Austin Hall, Harvard University, Middle Hall*

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

**Final Business**

Report of the Committee on Resolutions.
Report of the Committee on Membership.
Report of Other Committees.
Nomination of Journal Officers by Advisory Committee.
Report of Committee on Nominations.
Election of Officers.
Miscellaneous Business.
Fixing time and place of next Annual Meeting.
Final Adjournment.

W. E. HINDS, *President*,
*Baton Rouge, La.*

A. I. BOURNE, *Secretary*
*Amherst, Mass.*

JOURNAL
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VOL. 26 DECEMBER, 1933 No. 6

## Eighteenth Annual Meeting of the Pacific Slope Branch, American Association of Economic Entomologists

The 18th annual meeting of the Pacific Slope Branch was held at Utah State University, Salt Lake City, Utah, June 14 and 15. The meeting was called to order at 9:30 A. M. June 14. Papers were presented during the morning of the 14th and during the morning and afternoon of the 15th.

On the afternoon of the 14th, the visiting entomologists were conducted on a field trip under the leadership of Geo. I. Reeves and his assistants. The work on the alfalfa weevil was demonstrated.

The annual entomologists dinner was held on the evening of the 14th at the Temple Square Hotel.

The total attendance at the Salt Lake City meetings numbered 46, among which were the following members:

C. I. Bliss
L. D. Christenson
E. W. Davis
Louis G. Davis
R. A. Fulton
Chas. F. Henderson
Melvin J. Janes
Chas. R. Jones
Geo. F. Knowlton
Russell S. Lehman
Geo. M. List
G. Allen Mail
J. H. Newton
J. R. Parker
H. J. Quayle
Geo. I. Reeves
R. G. Richmond
H. A. Scullen
W. A. Shands
W. E. Shull
C. J. Sorenson
A. F. Swain
O. H. Swezey
R. L. Webster

## PART I BUSINESS MEETING

On Wednesday, June 14, the following committees were appointed:
Nominating committee: O. H. Swezey, C. R. Jones and J. H. Newton.
Resolutions committee: H. J. Quayle, W. E. Shull and J. R. Parker.
Auditing committee: C. I. Bliss, Russell S. Lehman.

Dr. C. I. Bliss gave an extended report with recommendations concerning the publication of the Journal of Economic Entomology. The

report was submitted by a committee appointed by former president Roy E. Campbell. After some discussion it was moved, seconded and carried that the report be considered as a special item of business during the Thursday program.

At the close of the program of papers June 15, the following business was transacted:

It was moved, seconded and carried that:

1. A committee be appointed to circularize the membership of the Pacific Slope Branch to determine the attitude in regard to suggested changes in the editing and make-up of the Journal of Economic Entomology;
2. This committee prepare a digest of the views of members obtained by the above method, which shall be forwarded at the earliest date possible to the Special Committee on Policy of the Journal of Economic Entomology.

The following committee was appointed by President Webster to carry out the above motion: H. J. Quayle, C. I. Bliss and E. M. List.

The auditing Committee reported favorably on the following financial statement of the Treasurer:

| | | |
|---|---|---|
| Balance on hand June 16, 1932 | | $20.27 |
| Interest | | .35 |
| Refund from parent society for 1932 meetings (received June 11, 1933) | | 9.81 |
| Cash paid out: | | |
| Postage and envelopes | $12.92 | |
| Telegram | 2.27 | |
| Labor (addressing letters) | 4.25 | |
| Mimeographing | 3.58 | |
| Balance on hand June 16, 1933 | $ 7.41 | |
| | $30.43 | $30.43 |

The committee's report was accepted.

The Resolutions Committee reported as follows:

*Be it Resolved*, That this Association express through its Secretary its appreciation to:

1. The University of Utah for providing rooms in which these meetings have been held; and for other courtesies which have been extended;

2. To Mr. George I. Reeves and his assistants for their untiring efforts in making local arrangements for meetings, field trips and the entomologists dinner.

Respectfully submitted,

J. R. PARKER
H. J. QUAYLE
W. E. SHULL

The committee's report was accepted.

The Nominating Committee submitted the following nominations:

President—G. I. Reeves
Vice-President—W. B. Herms
Secretary-Treasurer—H. A. Scullen

The committee's report was accepted and the officers duly elected.

It was announced that the 1934 meetings would be held at Berkeley, California.

# PART II PAPERS

## LIZARDS AS PREDATORS OF THE BEET LEAFHOPPER[1]

By G. F. KNOWLTON[2] and M. J. JANES[3]

ABSTRACT

In Utah during the past three years, 2659 lizards have been collected and their stomachs examined. Of 1573 *Uta stansburiana stansburiana* taken among host plants of the beet leafhopper, 915 stomachs contained a total of 9322 specimens of *Eutettix tenellus* (Baker). Of 213 *Sceloporus graciosus graciosus* taken among host plants of *tenellus*, 59 stomachs contained 239 specimens of this pest. Other lizard species in which one or more specimens of *tenellus* were found include *S. elongatus*, *Phrynosoma douglassii ornatissimum*, *P. platyrhinos*, and *Eumeces skiltonianus*.

The desert lizards of northern Utah appear to be largely entomophagous, catching and devouring large numbers of insects of various kinds and sizes. As a rule, a number of insects were contained in each stomach after feeding had occurred. As might have been expected, the lizards did not discriminate between injurious and beneficial insects. Some ladybird beetles, predacious bugs, parasitic Diptera, and parasitic Hymenoptera were taken, but by far the greatest numbers were injurious or non-beneficial forms. In general, the larger lizards more commonly fed upon larger insects, while smaller lizard species and immature individuals of larger species fed more extensively upon the smaller insects.

In the northern Utah desert breeding grounds of this insect pest, several species of lizards fed upon the beet leafhopper, *Eutettix tenellus* (Baker). The most abundant and important lizard predator of this insect was the brown-shouldered Uta. This tiny lizard seems to take the

[1]Contribution from the Department of Entomology, Utah Agricultural Experiment Station, in cooperation with the U. S. Bureau of Entomology.

[2]Associate Entomologist, Utah Agricultural Experiment Station, and Collaborator, U. S. Bureau of Entomology.

[3]Field Assistant, U. S. Bureau of Entomology, and Graduate Assistant, Utah Agricultural Experiment Station. Publication authorized by Director, May 22, 1933.

most readily available food during most of the season. When beet leafhoppers become more abundant in the fall, these lizards were frequently found under the plants most heavily infested. The importance of this lizard is more fully appreciated when it is realized that the stomach contents of a lizard seldom represents an entire day's feeding. It was found that 75 per cent of the nymphal and 35 per cent of the adult *tenellus* were digested beyond recognition within six hours; at the end of 24 hours, 90 per cent of the adults were likewise indistinguishable.

The method employed in collecting lizards for food-habit studies was to shoot them with a .22 rifle, using shot shells. The lizards were then labeled and placed in a 70 per cent alcohol solution, the stomach contents being examined microscopically when opportunity afforded.

The writers are indebted to Dr. P. N. Annand of the U. S. Bureau of Entomology, in charge of the cooperative beet leafhopper investigation, for suggestions and encouragement during the course of this study.

*Uta stansburiana stansburiana* (B. and G.). During the season March 1930 to April 1933, inclusive, 1746 specimens of the brown-shouldered *Uta* were collected, mostly in Russian thistle areas or among shadscale, sagebrush, or greasewood. Of 1573 stomachs examined from lizards taken among beet leafhopper host plants, 915 contained one or more *tenellus* (Table 1). The total number of *tenellus* recovered was 9322, representing an average of 10.1 beet leafhoppers per stomach. Heaviest feeding on the beet leafhopper occurred during late summer and fall, the peak being reached in October.

TABLE 1. SEASONAL IMPORTANCE OF *Uta stansburiana stansburiana* AS A PREDATOR OF *Eutettix tenellus* IN AREAS SUPPORTING COMMON HOST PLANTS OF THE BEET LEAFHOPPER—MARCH, 1930–APRIL, 1933—INCLUSIVE

| Month | Total No. lizards taken | No. lizards containing *E. tenellus* | No. *E. tenellus* contained | | | Average *E. tenellus* per stomach |
|---|---|---|---|---|---|---|
| | | | Adults | Nymphs | Total | |
| March | 9 | 2 | 2 | 0 | 2 | 1.0 |
| April | 19 | 2 | 2 | 0 | 2 | 1.0 |
| May | 20 | 3 | 4 | 0 | 4 | 1.3 |
| June | 31 | 3 | 5 | 1 | 6 | 2.0 |
| July | 56 | 14 | 24 | 5 | 29 | 2.0 |
| August | 349 | 158 | 671 | 216 | 887 | 5.6 |
| September | 694 | 348 | 859 | 2451 | 3310 | 9.5 |
| October | 384 | 377 | 578 | 4462 | 5040 | 13.3 |
| November | 11 | 8 | 22 | 20 | 42 | 5.2 |
| Totals | 1573 | 915 | 2167 | 7155 | 9322 | 10.1 |

Early-season feeding was represented only by adults of *tenellus*. A nymph was first found in a stomach in June, after which time the ratio of nymphs to adults gradually changed, until during September and October nymphs greatly outnumbered adults in the stomach contents. The

number of adults and nymphs consumed was about equal during November.

In several instances individual stomachs contained unusually large numbers of *tenellus*. One lizard collected among Russian thistle in Skull Valley 1.25 miles south Iosepa on October 8, 1932, contained 17 adults and 94 nymphs, a total of 111; another lizard taken at the same time contained 4 adults and 102 nymphs. Several stomachs were examined, each of which contained more than 75 *tenellus*.

The second most abundant species of insect taken by the lizards was *Geocoris decoratus* Uhl.; 386 stomachs contained one or more of this form; the total number of individuals of this species was 1046. Ants were third in importance as a source of food; 255 Uta stomachs contained 1038 specimens.

The insect content by orders in these lizard stomachs was as follows: Collembola, 296 specimens; Orthoptera, 131; Isoptera, 157; Odonata, 16; Neuroptera, 40; Thysanoptera, 12; Homoptera, 9829; Hemiptera, 2266; Coleoptera, 425; Diptera, 731; Lepidoptera, 418; Hymenoptera, 1474 specimens. Other contents were: Spiders, 370; mites, 201; lizards, 1 *Sceloporus graciosus graciosus;* round worms, 1; bird feathers, 2; and pebbles and plant fragments. In the spring, succulent plant material was sometimes taken. During summer and fall, practically all of the plant material was dry and apparently ingested by accident, as seems to have been the case with the sand, small pebbles, and the bird feathers.

Ants were found in greatest abundance in the stomachs of the 173 Utas collected in areas not supporting common host plants of *tenellus*. Stomachs of 52 such lizards contained a total of 268 ants. Locustidae was next; 25 stomachs contained 27 specimens. The insect content by orders for these 173 lizard stomachs was as follows: Collembola, 81 specimens; Orthoptera, 32; Odonata, 1; Neuroptera, 4; Homoptera, 104; Hemiptera, 62; Coleoptera, 57; Diptera, 35; Lepidoptera, 63; Hymenoptera, 324. Other contents were: Spiders, 23; mites, 2; scorpions, 1; and sand and plant fragments.

DIGESTION STUDIES. Of 293 *tenellus* nymphs fed to 58 lizards, 75 per cent were digested beyond recognition at the end of 6 hours, 96 per cent at the expiration of 12 hours, and only one nymph was recovered from a stomach where digestion had progressed beyond the 12-hour period. Six hundred and thirty-eight adult *tenellus* were fed to 91 Utas; of these, 34.1 per cent were no longer recognizable at the end of 6 hours, 81.0 at 12 hours, 89.3 at 24 hours, and 92.7 per cent were digested at the end of 48 hours.

PARASITISM OF INGESTED BEET LEAFHOPPERS. Dissection of 1870 *Eutettix tenellus* taken from stomachs of lizards collected mostly during October, 1932, showed that internal parasitism of these leafhoppers was no greater than that of *tenellus* collected in sweepings. Two *Pipunculus* parasites were found in the 168 adult leafhoppers dissected, and only 1 *Pipunculus* was taken from 1702 nymphal *tenellus*. The average percentage of parasitism in 3067 *tenellus* collected during October of 1932 in sweepings and by dissection was 1.46 per cent.

The brown-shouldered Uta is present in considerable abundance in most desert breeding areas of the beet leafhopper in northern Utah. Upon at least three occasions, when conditions for collecting were especially favorable, it was possible in one hour for one collector to take from 75 to 100 specimens of this tiny lizard.

*Sceloporus graciosus graciosus* (B. and G.). Seven hundred and twenty-six specimens of the sagebrush swift were collected from areas supporting Russian thistle, sagebrush, rabbitbrush, or greasewood.

Of these lizards, 213 were taken among common host plants of the beet leafhopper and 59 of the stomachs contained one or more *tenellus*. Total *tenellus* content was 239 specimens, representing an average of 4 per stomach. Ants constituted the most common source of food of lizards collected among beet leafhopper host plants; 127 stomachs contained 506 ants; Locustidae was third in order; 58 stomachs contained 64 specimens.

The insect content by orders for these 213 lizard stomachs was as follows: Orthoptera, 67; Isoptera, 1; Odonata, 1; Neuroptera, 1; Thysanoptera, 1; Homoptera, 305; Hemiptera, 176; Coleoptera, 101; Diptera, 25; Lepidoptera, 257; Hymenoptera, 651. Other contents were: Spiders, 49; scorpions, 1; and sand and plant fragments.

Five hundred and thirteen sagebrush swifts were collected in areas not supporting common host plants of *tenellus*, although an occasional stomach was found to contain a beet leafhopper. Ants were most abundant in the stomachs of these lizards; 200 stomachs contained 1248 ants. Locustidae was next most abundant; 170 stomachs contained 216 individuals.

A summary of the insect content by orders for these 513 lizard stomachs follows: Collembola, 2; Orthoptera, 219; Isoptera, 88; Neuroptera, 16; Thysanoptera, 1; Homoptera, 414; Hemiptera, 121; Coleoptera, 313; Diptera, 162; Lepidoptera, 218; Hymenoptera, 1465. Other contents were: Spiders, 32; scorpions, 1; round worms, 40; symphylids, 1; and sand and plant fragments.

The sagebrush swift was the second most abundant and important lizard predator of *Eutettix tenellus*. This predator also fed quite extensively on grasshoppers.

*Sceloporus elongatus* Stejneger. During 1932 two half-grown specimens of *Sceloporus elongatus* were collected among Russian thistle in the Uintah Basin in northeastern Utah; one contained an adult and the other a nymphal *tenellus*. No beet leafhoppers were found in the stomachs of twelve additional specimens taken among sagebrush and rabbitbrush.

*Phrynosoma douglassii ornatissimum* (Girard). Girard's short-horned toad was collected principally among greasewood, Russian thistle, and sagebrush. Twenty-four specimens were taken; one specimen collected 3.5 miles east of Cedar Creek, Boxelder County, on September 7, 1931, contained an adult *Eutettix tenellus*.

*Phrynosoma platyrhinos* Girard. Sixteen specimens of the desert-horned-toad were collected, principally from areas supporting Russian thistle, sagebrush, and shadscale. A specimen taken at Bovine Point in Boxelder County, on August 11, 1931, among shadscale, contained an adult *Eutettix tenellus*. Two specimens collected 2 miles east of Promontory, Boxelder County, on September, 1931, contained 1 nymphal and 1 adult *tenellus*, respectively. As predators of the beet leafhopper, horned toads appear to be of little importance.

*Eumeces skiltonianus* (B. and G.). One specimen of the western or Skilton's skink was taken in the foothills 3.5 miles west of Clover, Tooele County, on August 31, 1932. This lizard contained an adult *Euttetix tenellus*, probably taken upon a nearby plant of *Verbena bracteosa*.

*Crotaphytus wislizenii* Baird and Girard. Seventy-two specimens of the leopard lizard were collected; most of these were taken in Skull Valley among sagebrush, rabbitbrush, and junipers. Although a number of juvenile specimens of lizards were collected among host plants of the beet leafhopper, no *tenellus* were found in their stomachs.

*Uta levis* Stejneger. The Rocky Mountain tree Uta was collected in Uintah Basin, in northeastern Utah. Two specimens were collected among sagebrush and two among sagebrush and Russian thistle; beet leafhoppers were not found in the stomachs of these specimens.

*Sceloporus occidentalis biseriatus* (Hallowell). One specimen of the western blue-bellied lizard was collected 3 miles south of Iosepa in Skull Valley, Tooele County, in 1932, among redscale, *Atriplex rosea; Eutettix tenellus* was not found in its stomach.

*Cnemidophorus tessellatus tessellatus* (Say). Seventy-nine desert whiptail lizards were collected, principally from areas supporting sagebrush,

junipers, rabbitbrush, greasewood, and Russian thistle. No beet leafhoppers were found in the stomachs of these lizards.

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## INSECT TOLERANCE

By R. L. Webster, *Washington Experiment Station**

### Abstract

Reference is made to previous studies on the subject of resistance to insecticides with special reference to the San Jose scale (*Aspidiotus perniciosus*), the red (*Chrysomphalus aurantii*) and black (*Saissettia oleae*) scales of California, and to resistant strains of codling moth (*Carpocapsa pomonella*). In the field laboratory at Wenatchee, apples were sprayed with the oil-lead arsenate combination and a uniform deposit of between 60 and 65 micrograms arsenic per square inch of apple surface obtained. In 1930 an average control of 73.0 per cent was obtained. This dropped to 60.0 per cent in 1931, and to 36.0 per cent in 1932.

In a paper presented by Dr. A. L. Melander at the Atlanta meeting of the American Association of Economic Entomologists, evidence was presented which indicated that the San Jose scale at Clarkston, Washington, was more difficult to kill with concentrations of lime-sulphur which were effective elsewhere in the Pacific Northwest (1). It was inferred at that time that this scale insect had acquired certain resistance to lime-sulphur in this particular area and that such resistance had developed since 1902, at which time Piper's study of the effectiveness of lime-sulphur was conducted at Wawawai, Washington.

Resistance to Lime-Sulphur in Washington.—The two locations mentioned are on the Snake River in Washington, the last named about 16 miles from Pullman, the first, where most of Melander's work was conducted, about 34 miles from Pullman. Because of the bends of the river, the two locations are probably some 30 miles apart. Climatic conditions in the Snake River Canyon, which is some 2000 feet below the surface of the surrounding country, are, by reason of higher average temperatures, well adapted for raising fruit. The altitude at Clarkston is 757 feet, at Wawawai, 658 feet, and at Pullman, 2,500 feet.

In this first paper Melander showed that, while a 5 degree lime-sulphur resulted in 100 per cent control at Yakima and at Sunnyside, with this

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same treatment at Clarkston 8 per cent of the scale was still alive six weeks after treatment. Where a 3 degree lime-sulphur was used, no living scale was found at Yakima, one-half of one per cent at Sunnyside, and 13 per cent at Clarkston. When the concentration was cut down to 2 degrees Baumé, no living scale was found at Sunnyside, one-half of one per cent at Yakima, and 17 per cent at Clarkston.

Again in 1915 Melander reported further evidence of tolerance, based on investigations conducted in 1914 (2). While the San Jose scale was easily controlled with a 2, 3, or 5 degree lime-sulphur at Wenatchee, the control was somewhat less satisfactory at Yakima, more so at Walla Walla, and most unsatisfactory at Clarkston. In this series of experiments, a lime-sulphur concentrate, made at Clarkston and testing 34 degrees Baumé, was used and diluted accordingly.

Lime-sulphur has been used at Walla Walla probably as long as anywhere in the Northwest, and the 1914 studies showed that 55 days after spraying with a 5 degree lime-sulphur, 34 per cent of the scale was alive. At Clarkston, 50 days after spraying with 5 degree lime-sulphur, 39 per cent of the scale was alive.

Finally, in 1923, Melander reported on a 12-year study of the problem, his investigation dating back to experimental spraying in Clarkston in 1908 (4). At this time he pointed out that while "the scale in the lower Clarkston flats has throughout the investigation manifested an astounding resistance to polysulfide sprays . . . this resistance had reached its apparent maximum by the time this investigation was begun."

Control of San Jose Scale in Illinois.—Further evidence on the subject of resistance is offered by the failure of lime-sulphur to check San Jose scale in southern Illinois, as reported by Flint. (5) In this case a loss of over 1,000 acres of apple trees in southern Illinois during the period 1920–1922 was indicated. These trees had been treated annually with 32° Baumé lime-sulphur, one gallon to eight gallons of water. At Olney, 47 days after spraying, there was 11 per cent living scale.

It may be recalled that it was in another county of southern Illinois, farther west and across the state, that the experiments of Titus in 1902 first showed conclusively that lime-sulphur could be used in the eastern United States and result in effective scale control.

Resistant Red and Black Scale in California.—In August, 1919, Professor H. J. Quayle showed me resistant red scale, *Chrysomphalus aurantii*, at Corona, in southern California, which was at that time only just beginning to be recognized as such. In this instance lemon trees had been fumigated with heavy doses of cyanide, sufficient to injure foliage severely, and yet the red scale was not entirely killed.

Later, in 1922, Quayle (3) published a preliminary statement in which he pointed out that the red scale was more resistant to fumigation in Orange County and at Corona than elsewhere in California. In the same paper Quayle showed that the black scale, *Saissetia oleae*, in the Charter Oak district, was also becoming resistant to fumigation with hydrogen cyanide.

Woglum (6) further pointed out that both these scale insects had developed some degree of resistance but that the areas in which this resistance occurred were different in the two cases. He advanced the belief that the resistant red scale originated at Corona and the resistant black scale at Charter Oak. The two areas are separated from each other by a chain of hills.

In the period between 1907 and 1909 the red scale was not difficult to control with what was then known as the 75 per cent schedule, according to Woglum. In 1918 and later, the red scale became impossible to control in the resistant area, even in the same orchards, and with twice the dosage of cyanide fumigation.

Resistance of Codling Moth to Arsenical Poisons.—More applications during the season, increasing amounts of spray material, and a greater number of gallons per tree is the history of spraying practice for codling moth control in the Pacific Northwest. During the past seven or eight years fruit growers in the heart of the Wenatchee district have gone from a schedule of five cover sprays to one of six covers. They have increased the dosage of lead arsenate from two pounds to 100 gallons to three pounds and have applied even greater amounts of spray material. It is now common practice to use 25 or 30 gallons at each cover spray to larger trees on which a grower may expect to produce from 25 to 30 boxes of apples.

Losses from codling moth were more severe in 1932 in the Northwest than for many years. The previous year had been considered as one in which the insect had been difficult to control, but in 1932 undoubtedly the situation was far worse. Moth activity late in the season and the heavy carry-over of worms from the previous year are generally considered as being responsible for the unusual amount of wormy fruit. Another factor, more difficult to estimate, was in the attempt of the grower to economize on spray materials, due to general prevailing economic conditions. All these factors, however, do not seem adequate to explain the lack of control generally experienced by apple growers in the Northwest in 1932, especially in the Yakima and Wenatchee valleys.

That the codling moth may be gradually acquiring a resistance to spray materials is a notion advanced in recent years, with some little

evidence in this direction. Control of the insect has been especially difficult in the Grand Valley in Colorado, as well as in the Pacific Northwest. The investigations of Dr. W. S. Hough, who found that worms originating in Colorado were far more difficult to poison than those from Virginia, first gave evidence for such a belief so far as the codling moth is concerned (7 and 8). Hough also found that worms from the Yakima Valley were intermediate between the other two. Placed on sprayed

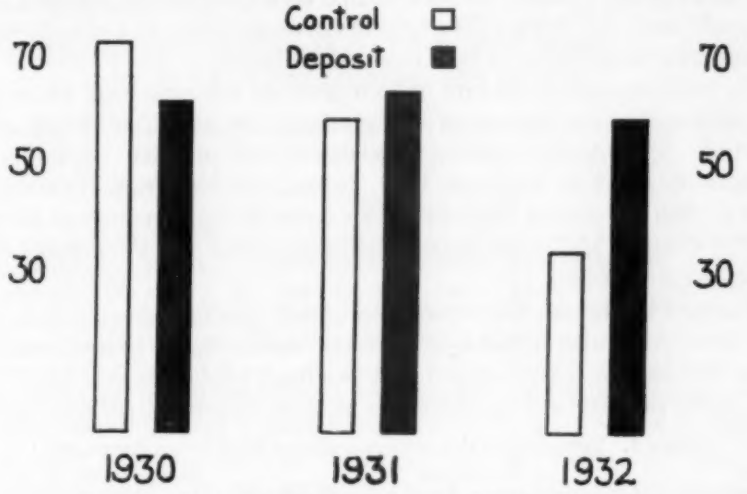


FIG. 84.—Control in laboratory with oil-lead combination.

apples in the laboratory, it was determined that while the lead arsenate permitted 15.5 per cent of the Virginia worms to enter, 33.2 per cent of the Washington worms made their way into the apples, while 51.5 per cent of the Colorado worms gained entrance. Both worms and stings were considered as entries in this study.

A comparison of three years of laboratory studies at Wenatchee in which the oil-lead arsenate combination was sprayed on apples indicates a decreasing effectiveness in lead arsenate in stopping the entering worms. In these tests, as reported by Webster et al, (9) the oil-lead arsenate was sprayed on apples in the laboratory and codling moth eggs in the "blackhead" stage were placed thereon immediately. There was no effect of the mineral oil, since the eggs, deposited on waxed paper, were pinned to the apples after the spray application. Such a test measures only the larvicidal value of any spray treatment. The same brand of lead arsenate was used throughout at the rate of two pounds per 100 gallons, to which was added one gallon of summer oil emulsion.

This is the usual oil-lead arsenate combination of the Pacific Northwest, especially valuable in the orchard during the early cover sprays and at the height of egg deposition.

At the time that the apples were sprayed, duplicate samples were turned over to C. D. Dolman, industrial chemist employed by the Wenatchee Valley Traffic Association, for analysis of the arsenical deposit. These analyses showed a uniform amount of arsenic during the three years, running between 60 and 65 micrograms per square inch of apple surface. With a film type of coverage, this has generally been considered as sufficient to stop most of the worms.

In 1930 an average control of 73.0 per cent was obtained, according to tests conducted by one of our graduate students, Mr. Thomas P. Strand. This dropped down to 60.0 per cent in 1931, according to results obtained by Kenneth D. J. Gillies, another graduate student, and to 36.0 per cent in 1932, when this series of experiments was carried out by Cecil E. Miller, graduate student employed on a Crop Protection Institute Fellowship.

Figure 84 indicates the difference in control in the laboratory during the three years with the oil-lead arsenate combination. In its consideration, it should be borne in mind that two most important field variables, i.e., moth population and variations in spray practices, are eliminated.

TABLE 1. THREE YEARS' LARVICIDAL TESTS WITH LEAD ARSENATE

| Year | Treatment | Larvae used | % control |
|---|---|---|---|
| 1930 | All brands Lead Arsenate—2 lbs.–100 gallons..... | 825 | 56.06 |
| 1931 | Corona Lead Arsenate—2 lbs.–100 gallons..... | 664 | 52.3 |
| 1932 | Corona Lead Arsenate—3 lbs.–100 gallons..... | 798 | 40.8 |

Similar results were obtained in the laboratory at Wenatchee when lead arsenate was applied without mineral oil. Since the 1930 and 1931 trials were on the basis of two pounds of the arsenical to 100 gallons of water, and the 1932 tests at 3–100, the comparison is not direct, yet the same trend is evident, even with a greater concentration in 1932.

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## DETECTION AND DETERMINATION OF SURFACE OIL ON CITRUS FOLLOWING SPRAYING[1]

By A. F. SWAIN and DON GREEN, *the Pacific R & H Chemical Corporation, El Monte, California*

ABSTRACT

Factors involved in the study of oil spray application are set forth, and methods available for such study are reviewed. Two new techniques are presented; one for the determination of extent of coverage by the use of an adherent powder, the other for the determination of surface oil films by means of a solvent wash. Illustrations of the range of application of the two techniques are given.

The use of petroleum oils as insecticides for the control of scale insects attacking citrus is based on the theory that the oils act as contact insecticides. If this be true, it follows that the effectiveness of any commercial treatment with petroleum oil depends not only on the degree of contact obtained, but also on the length of time during which such contact continues. In terms of application of the insecticide to the host plant, this means that coverage not only should be complete as regards amount of surface covered and quantity of oil deposited, but also should be of sufficient permanence to secure the desired results.

A proper and complete study of petroleum oil insecticides in relation to the effectiveness of application should include, therefore, information on the following factors:

1. Extent of coverage.
2. Quantity of oil deposited per unit area.
3. Disposition of oil after application.

Although a number of investigations have been in progress recently bearing on various aspects of the problem as a whole, no method has heretofore been published for the direct determination of the extent of

[1]Contributions from the Research Laboratories of The R & H Chemicals Department of E. I. du Pont de Nemours & Co. Inc., and the Pacific R & H Chemical Corporation.

coverage obtained with oil spray applications. Reliance has had to be placed on visual observations made immediately following treatment, while the water carrier was still present on the plant surfaces. When this had evaporated it was extremely difficult to determine with any accuracy just what portions had been properly covered. Smith (1), in studying citricola scale control with oils, has attempted to eliminate the factor of coverage from his results by assuming that the presence of live scale on a definite portion of a leaf on which the remaining scale were dead indicated that coverage was not obtained on that portion; whereas the presence of live scale scattered over the leaf indicated that the treatment was defective in some other manner. The resort to such an expedient only serves to emphasize the need for a simple and rapid method of detecting the presence and location of surface oil on the host plant, and such a method is consequently presented herewith.

Extensive studies of the oil depositing characteristics of petroleum insecticides have been made by various investigators in recent years. English (2) in 1930 described a method of ether extraction of the oil from discs cut from leaves. Later Dawsey & Haas (3) made refinements in this method, particularly by removing the natural oils and waxes from the extract and recovering the pure mineral oil. By this method it is possible to determine the quantity of oil deposited on the portions of the leaves that are used as samples. Although the method is limited because it is too laborious to be easily applied in the field, and because it is only applicable to determination of deposition on leaf surfaces, still Allison (4) has used it to study such factors as the influence of character and amount of spreader, type of spray application, and "heaviness" of the oil, on the amount of oil deposited.

The problem of oil disposition following application is considered to depend upon two factors: first, penetration into the plant tissue and second, evaporation from the surface film. Extensive studies of oil penetration into the plant tissues through a sectioning and staining technique have been made by Knight and his co-workers (5), who made observations on such penetration where an extremely heavy deposit of oil was made; and later by Rohrbaugh (6), who studied penetration following spray operations. The technique used is, however, highly specialized and is not applicable to an extensive study. Some such method as that of English could be used for the study of evaporation of oil from the surface film, since such a method determines all the oil present both on and within the plant tissue. If this method were supplemented by a method for determining only surface oil films, such as is presented below, complete information on oil disposition would be

obtained, since penetration could be calculated by the difference between total oil and surface oil.

DETECTION OF SURFACE OIL FILMS.—The possibility of detecting free oil on leaf surfaces by means of adherent powders such as are used in finger print detection, was conceived by Pittman & McGovern (7). They made tests, using ash leaves, with zinc stearate, diorthotolyl guanidine, formaldehyde analine, talc, face powders and aluminum powder. Of these materials talc and aluminum powder gave the best adherence on oiled surfaces, and aluminum powder was selected as preferable because of better color contrast obtained.

The authors found that aluminum powder when used on orange leaves adhered slightly to unoiled leaves. Consequently further tests were made, chiefly with colored powders and pigments such as lamp black, kelp charcoal, willow charcoal, iron oxide, zinc oxide, manganous oxide, magnesium carbonate, talc, colloidal clay, and flowers of sulfur.[2] Of these materials the sulfur was outstandingly superior to any of the others, in that it did not adhere in the least to unoiled leaf surfaces, but was extremely sensitive to minute films of oil (Plate 47A). The color contrast was such that the slightest trace of sulfur against the green leaf as a background could be easily seen.

*Method:* Place flowers of sulfur in a can or bottle of convenient size covered with cheese cloth or fine wire screen. Sift an excess of the sulfur onto the surface to be tested, invert the surface and shake moderately. Apply a second coating of sulfur, shake off the excess, and finally blow off with the breath any remaining loosely-held sulfur.

MEASUREMENT OF SURFACE OIL FILMS.—In an attempt to devise a practical analytical method for quantitative determinations of oil films on citrus foliage a number of procedures were scouted, both by Pittman and McGovern and the authors. Among the procedures tried and abandoned were the measurement of oil films imparted to water from oiled leaves, the quantitative measurement of absorbent powders, and direct weighing techniques. The method finally adopted was originated by Pittman and McGovern and developed by the authors. It consists essentially in washing the leaf surfaces with an oil solvent, evaporating the solvent and weighing the residual oil. Several solvents were tried, including ethyl ether, petroleum ether, heptane, and methylene chloride. Methylene chloride[3] was selected because of its consistently

[2]It is important to use the sublimed flowers of sulfur rather than any of the ground dusting sulfurs inasmuch as the latter adhere quite tenaciously to unoiled leaf surfaces.

[3]Methylene chloride (dichloro-methane, $CH_2Cl_2$) is a colorless liquid: M. W. = 84.9; B. P. (°F at 1 atm.) = 105; Sp. Gr. (water = 1) = 1.35 (8).

low extraction on untreated leaves and its consistently high percentage recovery on oiled leaves. Technique using methylene chloride is given below.

*Method:* Wash the surfaces to be tested with a spray of methylene chloride, allowing the washings to run into a beaker. Filter the combined washings through a Munktell quantitative filter paper into a weighed evaporating dish, washing the filter thoroughly with fresh solvent. Evaporate the solvent on a water bath maintained at 45°C., dry the dish in an oven at 45°–50°C. for 2 hours, cool in a desiccator and weigh. Calculate to milligrams of oil per 100 square centimeters of surface area.

*Notes on Technique:* In no case should samples be washed with the solvent before they have dried from the spray treatment. Under ordinary field conditions this requires from one to two hours after spraying.

The sample taken should, for the sake of reasonable accuracy in area determinations, be not less than 10 individual leaves, and for the sake of accuracy in weighing technique, should yield not less than about 30 milligrams of oil.

The washing should be performed in such a manner as to avoid cutting into the waxy leaf covering with the solvent. For this purpose the authors used a wash bottle constructed from the body of a gasoline blow-torch (Plate 47B). The torch part was removed and a whistle valve operating by means of a lever was connected to the fluid outlet. To the valve was connected a short copper tube terminating in a burner tip with small outlet hole. The fine stream of solvent issuing from the burner tip was made to impinge upon a flat plate adjusted just below it so that the stream was broken into a flat fan-shaped spray. With the spray properly adjusted, the leaf surface could be washed very quickly and thoroughly without appreciably disturbing the waxy coating.

*Blank and Check Analyses:* Certain blank tests were made by treating leaves and glass plate blanks simultaneously and determining oil films on both. This method was soon found to be unreliable due to rapid absorption of oil into the leaves with consequent low apparent results. For this reason the method has been checked only indirectly by determining the loss on a weighed quantity of spray oil subjected to the analytical procedure, and by determining the amount of residue obtained from untreated leaves subjected to the analyses. Blanks on oils show a loss of 3–5% with light oils, and less with heavy oils. The residue obtained on treating blank leaves has been found to vary from 0 to 0.7 milligrams per 100 square centimeters of surface area. Since these factors tend to balance out, and are within the limits of accuracy considered

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A—Flowers of Sulfur used to indicate the location of free mineral oil on the surface of an orange leaf.

B—Leaf Washing Device used by the authors in the determination of free surface oil

practical in this work, correction factors have not been used by the authors on results obtained by the methylene chloride method.

*Determination of Surface Areas:* Since the results are reported in terms of weight of oil per unit of surface, it was necessary to devise a rapid practical means of approximating the amount of surface used. Most of the work done so far has been on leaves, so fruit or wood surface has therefore been approximated merely by calculating the area of a cylinder or sphere respectively from the average of maximum and minimum circumference measurements.

A more elaborate study was made in determining an approximate formula for surface area calculations on leaves. To avoid the necessity of measuring the area of each leaf with a planimeter, an empirical equation was calculated from measurements of over 200 Valencia orange leaves. With leaves whose midrib length from tip to petiole is not less than 8 cm. or more than 12 cm. there is a definite relationship between the product of the length times the width and the actual area. When the ratio $\frac{\text{area}}{\text{length x width}}$ is plotted against the length times width product a straight line curve is formed in these limits[4], as is shown in Figure 85. With smaller leaves the ratio drops off markedly, while with larger leaves the variation is too great for the method to be reliable. In practise, average sized, normally shaped mature leaves are chosen, the length and width measured and the area calculated to the nearest square centimeter either from the graph or from Table 1.

TABLE 1. FACTORS FOR CALCULATION OF LEAF AREAS

| Length x width Product in sq. cm. | Multiplied by factor to obtain area |
|---|---|
| 25–33 | .64 |
| 33–47 | .65 |
| 47–62 | .66 |
| 62–76 | .67 |
| 76–90 | .68 |

DISCUSSION.—The use of sulfur to detect oil films was thoroughly tested, both in the laboratory and in the field. Results with it were found to be entirely satisfactory within the following limits of application:

1. The sulfur dust is very sensitive, but only to free surface oil.

[4]The equation for this curve is $Y = .0007X + .622$, where $Y = \frac{\text{area}}{\text{length x width}}$ and X = length x width. The variation of individuals from this curve is noted by the standard deviation ($\delta = .005$) which is relatively small.

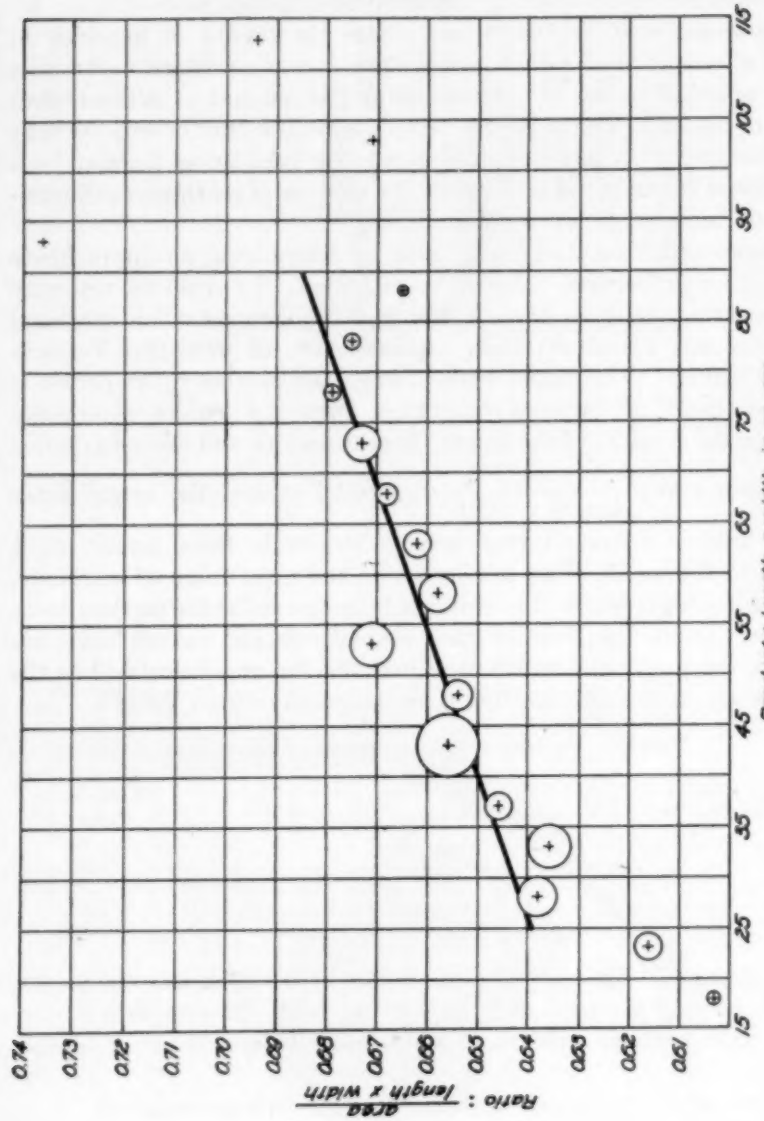


Fig. 85.—Area of valencia orange leaves based on measurements of length and width.

2. The presence of dust on leaf surfaces does not interfere with the test, although tests should not be made when foliage is wet.

3. The amount of sulfur dust retained by the leaf surfaces can be used to indicate visually differences in amounts of oil of a ratio of 1:2 or greater, provided that the lightest deposition checked does not exceed about 30 milligrams of oil per 100 square centimeters of surface.

The practical value of this method for detecting the presence of oil films on foliage depends largely on the facility with which it can be applied in the field. It can be used to check rapidly and thoroughly the effectiveness of any oil spray treatment in terms of coverage efficiency by testing samples taken from different locations in the trees treated. Dorsal and ventral leaf surfaces can be checked separately and checks can be made on twigs and fruit. In this connection, it should be observed that the oil absorption rates of different parts of the tree vary greatly and consequently comparisons of deposition on different parts of the tree should be made as soon as possible after the moisture from the spray has evaporated.

A laboratory test may be used to illustrate the use and limitations of the sulfur dust method. A group of leaves were treated with oil simultaneously, in such a manner that the exposed surfaces of all received approximately the same amount of oil per unit area. Half the leaves exposed the dorsal surface, and half the ventral surface. A leaf from each group was tested at given intervals by the sulfur dust method. Leaves tested immediately after treatment showed about one-third less oil on the ventral than on the dorsal surface. After six hours hardly any oil remained on the ventral surface, whereas at the end of eight hours there was only a slight decrease of oil from the dorsal surface. The sulfur dust showed traces of oil remaining on the dorsal surface for more than 10 days after treatment.

The methylene chloride surface washing method presented is applicable to the determination of total oil deposited by petroleum insecticides provided that the determination is made before any appreciable penetration of the oil into the plant tissues has occurred. This can be accomplished most satisfactorily by sampling the dorsal leaf surfaces as soon after application as possible. Characteristic results obtained by determining total deposition of oil in this manner are given in Table 2, where the quantity of oil deposited by different degrees of thoroughness of application of the same oil spray is shown.

This method is also admirably adapted to the determination of that portion of the original oil which remains as an effective insecticide at any given time, as it measures only the oil present on the host surface.

TABLE 2. LABORATORY TEST, CITRUS CUTTINGS, 2% LIGHT OIL EMULSION

| Degree of application | Mg. Oil/100 sq. cm. dorsal leaf surface |
|---|---|
| Light | 3.0 |
| Average | 6.5 |
| Average | 6.5 |
| Average | 6.5 |
| Average | 7.5 |
| Heavy | 16.5 |

It is a well known fact that the efficiency of oil sprays on citrus varies greatly between the different morphological parts of the tree (9). This

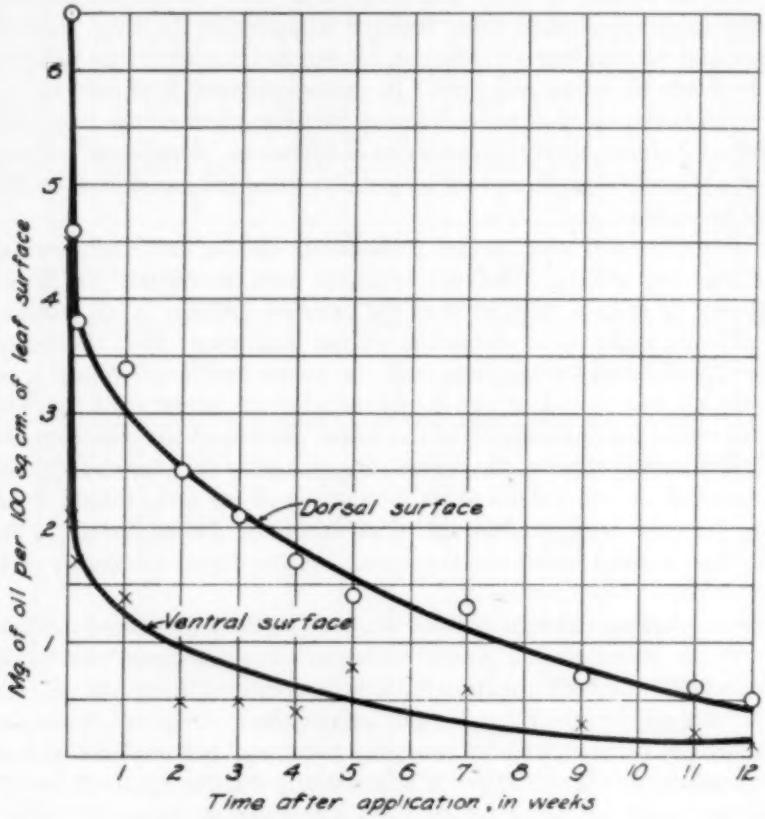


Fig. 86.—Permanence of oil film on foliage.

is due, at least partially, to the fact that oil deposition and retention are influenced by the type of surface. By means of the methylene chloride surface washing method, the amount of oil retained by any

surface at any time can be readily determined. Table 3 contains representative results on the determination of the oil present on three different surfaces of lemon trees about one hour after they were sprayed commercially with a medium oil emulsion at 2% dilution.

TABLE 3. QUANTITY OF OIL RETAINED BY DIFFERENT HOST SURFACES

| Surface | Mg. oil/100 sq. cm. |
|---|---|
| Leaf (dorsal) | 6.0 |
| Leaf (ventral) | 5.0 |
| Fruit | 6.5 |

There are numerous features related to the problem of the deposition and retention of surface oil films which are adaptable to study by means of the methylene chloride surface washing method. The results of very brief studies of two such features are presented as illustrating the scope of application of the method. The first study is on the rate of decrease of surface oil as influenced by the time interval following application. The accompanying graph (Fig. 86) shows the rate of decrease of surface oil from both dorsal and ventral leaf surfaces of lemon following a commercial oil spray treatment. The second study is on the effect of type of emulsion on oil film permanence. Table 4 shows the quantity of oil found on the dorsal leaf surfaces of citrus seedlings where three types of oil sprays were used, (a) a permanent emulsion, (b) a commercial emulsion of the "quick breaking" type, and (c) a mechanical mixture of oil and water with a small amount of spreader.

TABLE 4. OIL DEPOSITION AND RETENTION AS AFFECTED BY TYPE OF EMULSION

| Type of spray | Mg. oil/100 sq. cm. 1 hour after application | 2 weeks after application | Per cent loss from surface in 2 weeks |
|---|---|---|---|
| a | 5.1 | 2.7 | 47 |
| b | 8.6 | 3.3 | 62 |
| c | 8.4 | 2.7 | 68 |

The above illustrations are only a few examples of the possible uses of the methylene chloride surface washing method. They indicate, however, that by its use much valuable information concerning petroleum insecticides can be obtained since a direct study can be made of the characteristics of the surface oil film deposited by the insecticide, and it is obvious that in studying the oil remaining on the sprayed surface, a study is being made of that portion of the oil deposited that has insecticidal value.

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**Fall canker worm,** *Alsophila pometaria* Harris, was extraordinarily abundant and injurious in southwestern New England and southeastern New York last spring, and naturally there has been a serious question as to whether there would be a repetition of the outbreak next year. It is well known that extreme abundance of various insects is normally followed by a great reduction due to natural causes, and in the case of the apple tent caterpillar it is undoubtedly true that parasites and possibly predators are important elements in bringing about this natural control. The factors producing the well known fluctuations in the abundance of the fall canker worm are not so well known. The insects are already issuing at the time of writing, mid-November, and as yet it is early to forecast probabilities as to the abundance of the canker worms next spring. There certainly will be some, and judging from earlier experience with this insect it is quite probable that they will be relatively more abundant in areas where they were not extremely numerous last spring, and that in the more densely infested sections of last spring there is a possibility of some and perhaps a material reduction in the numbers of these pests. There is an excellent opportunity to obtain data upon the situation, and it is hoped that entomologists and other observers in the areas which suffered severely last year will make note of conditions the coming spring and advise as to the outcome.

E. P. FELT

# STUDY OF AUXILIARY GASES FOR INCREASING THE TOXICITY OF HYDROCYANIC GAS[1]

## Part I. Studies with Ladybird Beetles as Indices of Toxicity[2]

By F. S. PRATT, A. F. SWAIN and D. N. ELDRED, *the Pacific R & H Chemical Corporation, El Monte, California*

ABSTRACT

In the studies reported here, almost 200 chemicals covering a wide range of organic and inorganic compounds were used in qualitative and toxicity tests for the purpose of determining their action on ladybird beetles in conjunction with HCN. It was found that several were toxic in themselves, but few approached HCN in degree of toxicity. Some were very irritating to the insects, and some were stupefying. In general it was found that those compounds whose vapors were effective in increasing the toxicity of HCN were either predominantly toxic, or moderately toxic and irritating. The majority of compounds having value fell in the latter class. Certain of the gases which stupefied the insects actually decreased the toxic action of HCN. The vast bulk of the compounds had apparently no effect, neither increasing nor decreasing the toxicity of HCN.

Fumigation of citrus trees with hydrocyanic acid for the control of scale insects has been practised for almost half a century in California. Until comparatively recently most species of scale infesting citrus have been readily controlled by fumigation and at present this method plays an exceedingly important part in the field of citrus pest control However, in certain restricted areas in Southern California, there have developed scale that are able to withstand concentrations of HCN which in turn cause injury to the host plants. In other words, certain species of these scale have either built up a tolerance to HCN through successive generations or developed new strains of such a hardy character that normal dosages of HCN are not effective.

Since this is a condition that must be met, it appears that a possible method of so doing consists in increasing the toxicity of HCN to the insects. One means of accomplishing this would be the addition to HCN of some auxiliary gas which would improve the control of scale, either by its own toxic action or by its increasing the toxicity of HCN[3].

[1]Contribution from the Laboratories of the Pacific R. & H. Chemical Corporation.

[2]This is a report of the preliminary studies made using ladybird beetles as indices of toxicity. Later papers will report studies with various of the scale insects infesting citrus orchards in Southern California.

[3]The idea that formaldehyde, which seems to be irritating to some insects, might irritate or stimulate scale and thereby render it more susceptible to HCN was advanced by Neuls (1). He performed some tests using HCN plus formaldehyde, and other tests with HCN alone, using ladybird beetles as the index of toxicity. These experiments seemed to indicate that 0.15% formaldehyde in the atmosphere increased the killing efficiency of HCN concentrations varying from 0.05% to 0.25%, both gases reported as per cent by weight in air.

From the beginning of the study undertaken to search out auxiliary gases which would add to the toxic effect of HCN, those engaged in the work herein reported held the viewpoint that the auxiliary gas might be irritant, toxic or non-toxic, but that any effect such as irritating, stimulating or stupefying might add to the toxicity of HCN.

In order to investigate as thoroughly and completely as possible the whole field of chemical substances the following basis of selection was used:

(1) Chemical structure: representatives of classes of inorganic and organic substances.

(2) Chemical characteristics: boiling point not too high; vaporization feasible, not decomposed; preferably not chemically reactive with HCN.

(3) Chemical warfare data on toxic and irritating gases.

(4) Cost: giving preference to substances which could be produced at a cost feasible for this use.

It is to be understood that substances to qualify as fumigants must be in the form of a gas or vapor. Liquids of boiling points much higher than atmospheric temperature were vaporized by a suitable heating coil, and these substances then existed as vapors carried in the air.

When any substance or compound was found to have some value, other compounds of related chemical structure were tested.

TABLE 1. COMPOUNDS TESTED FOR TOXICITY TO INSECTS
Alone or in Combination with HCN

| | | | |
|---|---|---|---|
| Acetates | 9 | Iodides | 1 |
| Acids (organic) | 5 | Inorganic compounds | 24 |
| Alcohols | 12 | | |
| Aldehydes | 14 | Ketones | 7 |
| Benzene derivatives | 12 | Nitrates | 2 |
| Bromides | 9 | Nitriles | 2 |
| Butyrates | 1 | Nitrites | 3 |
| | | Nitro compounds | 5 |
| Chlorides | 21 | Nitrogen compounds | 2 |
| Chlorhydrins | 3 | | |
| Cyanogen compounds | 8 | Oils | 6 |
| Esters | 5 | Phenols | 7 |
| Ethers | 7 | Propionates | 1 |
| Formates | 3 | Sulphur compounds | 7 |
| | | Miscellaneous compounds | 5 |
| Hydrins | 1 | | |
| Hydrocarbons | 8 | Total | 190 |

The ultimate aim of this study was improvement in the control of scale insects infesting citrus and the value of any auxiliary fumigant could be given finally only in terms of toxicity to these scale. However,

for preliminary studies, it was believed that through the use of active insects valid indications could be obtained with greater ease and more rapidity than through the use of scale insects. The responses of the latter to stimuli are difficult to observe, several days following treatment are required for the determination of toxicity and wide variations in natural mortality occur. Previous studies (2, 3) had indicated that certain adult ladybird beetles were satisfactory in as much as their reactions were marked, mortality could be determined within 24 hours, abundant supplies were readily available, and the toxicity of HCN to the beetles was approximately the same as to adult red scale.

In the first series of experiments three species of ladybird beetles and one of granary weevils were used. Cryptolaemus beetles (*Cryptolaemus montrouzieri* Muls.) were obtained from a local insectary, the convergent ladybird beetle (*Hippodamia convergens* Guerin) and its variety *H. ambigua* LeConte from hibernating colonies in the nearby mountains and the granary weevil (*Sitophilus granarius* (Linn.)) from an infested flour mill. Preliminary toxicity tests (Table 2) showed that the granary weevil was unaffected by the lower concentrations of HCN toxic to ladybird beetles and that results with Cryptolaemus were more variable than with the convergent ladybird beetle. Consequently results reported in this paper have been limited to those obtained with the ladybird beetle, *H. convergens* Guerin.

TABLE 2. PRELIMINARY TOXICITY TESTS

Toxicity of HCN alone to four insects
Per cent kill of insects
Ladybird beetles

| Per cent HCN | Exposure in minutes | *Hippodamia convergens* | *Hippodamia ambigua* | *Cryptolaemus montrouzieri* | *Sitophilus granarius* |
|---|---|---|---|---|---|
| 0.2 | 10 | 85 | 70 | 15 | 0 |
| | 20 | 95 | 95 | 95 | 0 |
| | 30 | 100 | 100 | 100 | 0 |
| 1.0 | 30 | | | | 20 |
| 2.0 | 30 | | | | 30 |
| 3.0 | 30 | | | | 90 |
| 4.0 | 30 | | | | 100 |

QUALITATIVE STUDY OF GASES.—In order to observe the effects on insects of a large number of gases, under fairly uniform conditions, and in a reasonably short period of time, a qualitative method was devised. This was intended to be preliminary or scouting in nature, and served to indicate which compounds might deserve more thorough investigation.

*Method:* The method used in making uniform qualitative tests was to place several insects in a glass cell and circulate air carrying a known

concentration of the gas through the cell. The desired concentration of the gas was established in a large glass bottle by an appropriate measurement, vaporizing a measured quantity of liquid when that was the form received. The atmosphere in the bottle was circulated from the bottle through the observation cell and returned to the bottle by means of a mercury pump (Plate 48).

The concentration of gas in air to be used was decided upon as 0.20% by weight. There were good reasons for selecting this amount: (a) HCN was the standard of comparison, and 0.20% HCN by weight in air had been found to give a 100% kill of beetles with a minimum exposure from 20 to 30 minutes; (b) this concentration and exposure, when converted to commercial operating conditions, probably represents the maximum amount which could be used on the basis of such considerations as cost and human tolerance. Formaldehyde, for example, was found to be intolerable to workmen when introduced under tents at 0.05% or stronger.

A constant concentration of the test gas in air was used throughout these qualitative tests, rather than the typical decreasing concentration found in tree fumigation, because this served the purpose of providing comparable results with the most simple equipment.

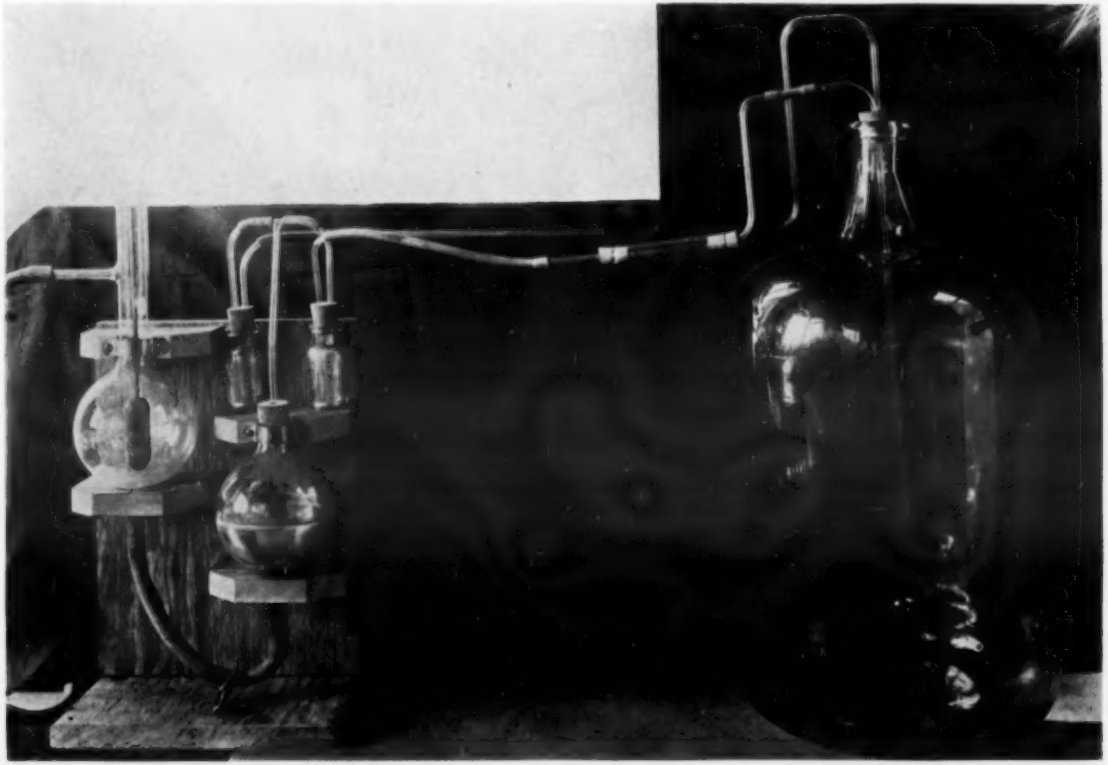
The insects were observed for a period of exposure of 30 minutes and their visible reactions during this time recorded. At the end of the 30 minutes exposure the beetles were collected in a small cotton sack and set aside in fresh air for 24 hours, at which time they were examined to determine whether dead or alive; if not active they were placed on a watch glass over a hot plate and gradually warmed, after which, if still inactive, they were recorded as dead.

In order to standardize the record of effects noted, the following terms were used, referring to beetles:

(1) Very active; flapping wings, crawling.
(2) Active: Crawling.
(3) Inactive: Not crawling, but able to move.
(4) Stupefied: Slight movement, such as lifting legs occasionally.
(5) Dormant: No movement.
(6) Dead.

The following table (Table 3) is an example of the type of study made and the method used in recording the observations.

*Classifications of Gases by Effects.* Judging by the predominating reactions resulting from 30 minutes exposure to 0.2% by weight in air of each gas, the more significant results were as follows:



Apparatus for Qualitative Study of Gases, for Observing Visible Effects on Insects. Large glass bottle acts as gas chamber and mercury pump serves to circulate gas through observation cell and returns to bottle.

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1. Strongly toxic (100% kill in 30 minutes): hydrocyanic acid, cyanogen chloride, hydrogen chloride, thionyl chloride, camphor.

TABLE 3. QUALITATIVE OBSERVATIONS: EFFECTS OF GASES ON BEETLES AND WEEVILS

SALICYL ALDEHYDE, 0.2% in air. Room temp.: 24°C.
Exposure: 30 minutes Rel. hum.: 52%

| Time of observation | *H. convergens* | *H. ambigua* | *C. montrouzieri* | *S. granarius* |
|---|---|---|---|---|
| 1 minute | active (irritated) | active (irritated) | active (irritated) | active |
| 3 minutes | very active | very active | very active | active (irritated) |
| 5 minutes | " " | " " | " " | " |
| 10 minutes | stupified | active | 3 dormant, 2 stupified | " |
| 20 minutes | stupefied | stupefied | stupefied | inactive |
| 30 minutes | stupefied | stupefied | 3 dormant, 2 stupefied | " |
| 24 hrs. later | all dead | all dead | 2 dead | all alive |

CARBON DIOXIDE, 100% atmosphere. Room temp.: 26°C.
Exposure: 30 minutes Rel. hum.: 46%

| | | | | |
|---|---|---|---|---|
| 1 minute | stupefied | stupefied | stupefied | stupefied |
| 3 minutes | dormant | dormant | dormant | dormant |
| 5 minutes | " | " | " | " |
| 10 minutes | " | " | " | " |
| 20 minutes | " | " | " | " |
| 30 minutes | " | " | " | " |
| 24 hrs. later | all alive | all alive | all alive | all alive |

Note: *H. convergens* and *H. ambigua* will survive an exposure of *4 hours* to 100% $CO_2$ atmosphere

HYDROGEN, 100% atmosphere. Room temp.: 23°C.
Exposure: 30 minutes Rel. hum.: 66%

| | | | | |
|---|---|---|---|---|
| 1 minute. | stupefied | stupefied | stupefied | stupefied |
| 3 minutes | dormant | dormant | dormant | dormant |
| 5 minutes | " | " | " | " |
| 10 minutes | stupefied | stupefied | " | " |
| 20 minutes | " | " | " | " |
| 30 minutes.... | " | " | " | " |
| 24 hrs. later | all alive | all alive | 3 dead | all alive |

NITROGEN, 100% atmosphere. Room temp.: 23°C.
Exposure: 30 minutes Rel. hum.: 68%

| | | | | |
|---|---|---|---|---|
| 1 minute | stupefied | stupefied | stupefied | stupefied |
| 3 minutes | dormant | dormant | dormant | dormant |
| 5 minutes | " | " | " | " |
| 10 minutes | " | " | " | " |
| 20 minutes | " | " | " | " |
| 30 minutes | " | " | " | " |
| 24 hrs. later | all alive | 2 dead | all dead | all alive |

2. Toxic and irritating (partial kill in 30 minutes): salicyl aldehyde, benzaldehyde, allyl iso-thiocyanate, chloropicrin, benzyl bromide, brom benzyl cyanide, thiophenol, cyanogen, phosgene, allyl bromide, acetophenone, creosote, ethylene-chlorohydrin, (hydrogen 100%), pyrethrum powder.

3. Non-toxic and Irritating: benzyl chloride, xylyl bromide, acetic acid, eucalyptus oil, carbon tetrachloride, pyridine, bromine, nicotine.

4. Stupefying: carbon dioxide, carbon monoxide, hydrogen sulphide, hydrogen iodide, phosphine, arsine, ethyl alcohol, n-propyl alcohol, iso-propyl alcohol, amyl alcohol, n-butyl alcohol, trichlor ethylene, nitrobenzene, benzene, monochlor benzene, furfuraldehyde.

5. No effect (or slight effect): 67 or more compounds tested.

TOXICITY STUDIES OF GASES WITH HCN.—On the basis of the observations made in these tests as to the visible reactions of the beetles to the various gases, toxicity studies of selected gases in conjunction with HCN were carried on. Results were based on replicated tests with comparatively large numbers of beetles in terms of per cent kill, the object being to shorten the time to kill 100% through the use of an auxiliary gas with HCN, as compared to the time required to obtain 100% kill with HCN alone.

*Technique of Toxicity Studies.* Supplies of *H. convergens* Guerin were collected periodically from colonies in the nearby mountains and were kept in a mixture of leaves and earth in an ice box. As required, beetles were removed from the supply, warmed in an electric oven at 40°C. until active (usually 5 minutes was sufficient), after which 20 were placed in a small cheesecloth bag for use.

In a gas-tight chamber (usually a 46 liter glass bottle) a concentration of the auxiliary gas at 0.1% in air by weight was obtained. Into this 6 bags of beetles were introduced and after 10 minutes exposure, sufficient HCN was added to make a concentration of 0.2% HCN in air by weight. Five minutes later one bag of beetles was removed, and at the end of each 5 minute period thereafter another bag was taken out. These were placed in suitable storage until the next day when mortality counts were made. Any beetles that did not show signs of life on examination were warmed for a few minutes in a watch glass over a heater and if this did not cause them to show life, they were considered as dead. One check test with HCN at 0.2% concentration was made each day, while at least 5 separate tests on two days were made with each auxiliary gas.

*Basis of Classifying Results.* In order to judge results toxicity curves were drawn up for HCN alone and in combination with other gases. In these the percent kill was plotted over the time of exposure at 5 minute intervals. A large series of tests with HCN alone were made, using concentrations of 0.1, 0.2, 0.3, and 0.4% in air by weight. In figure 87A are shown the toxicity curves obtained.

In the cases of the auxiliary gases with HCN the toxicity curves of the combination was plotted together with that of HCN alone at 0.2% in air

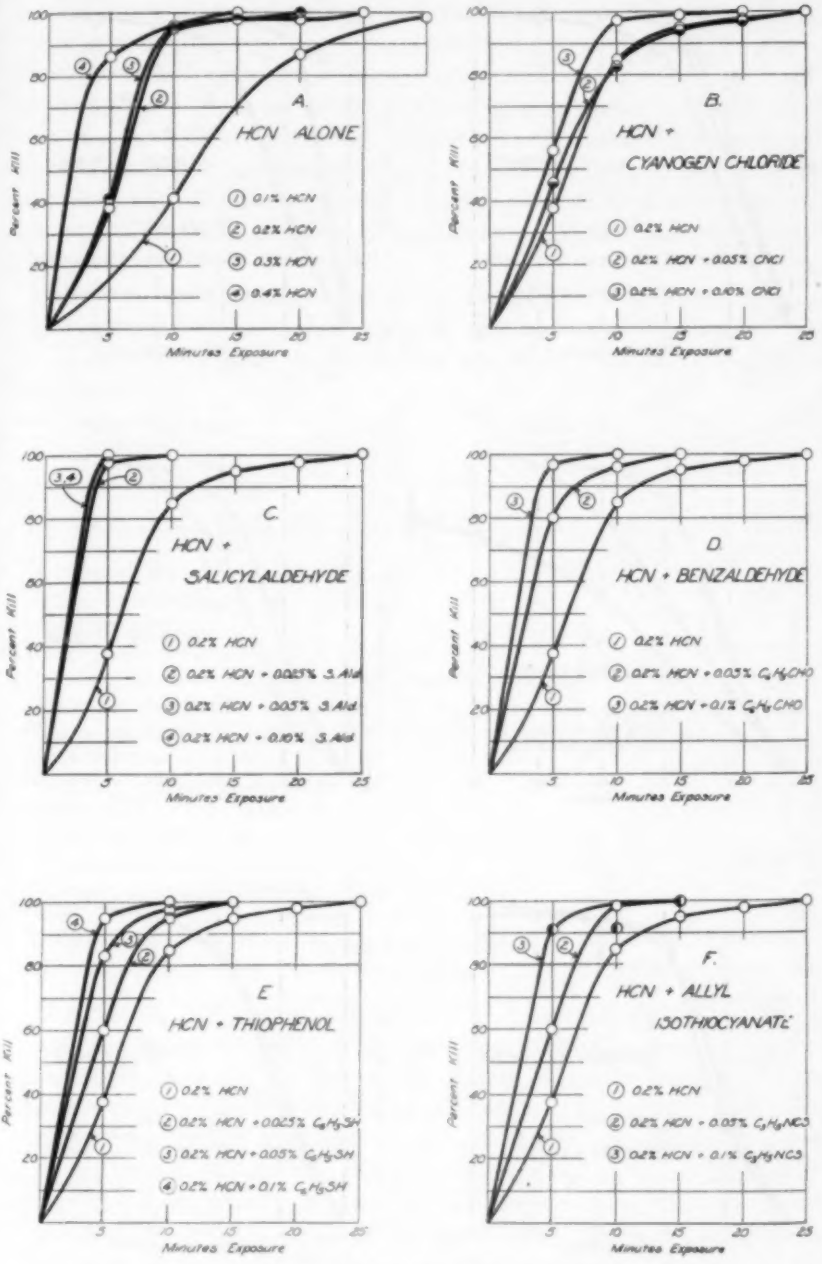


FIG. 87.—Toxicity Curves—Auxiliary Gases with HCN.

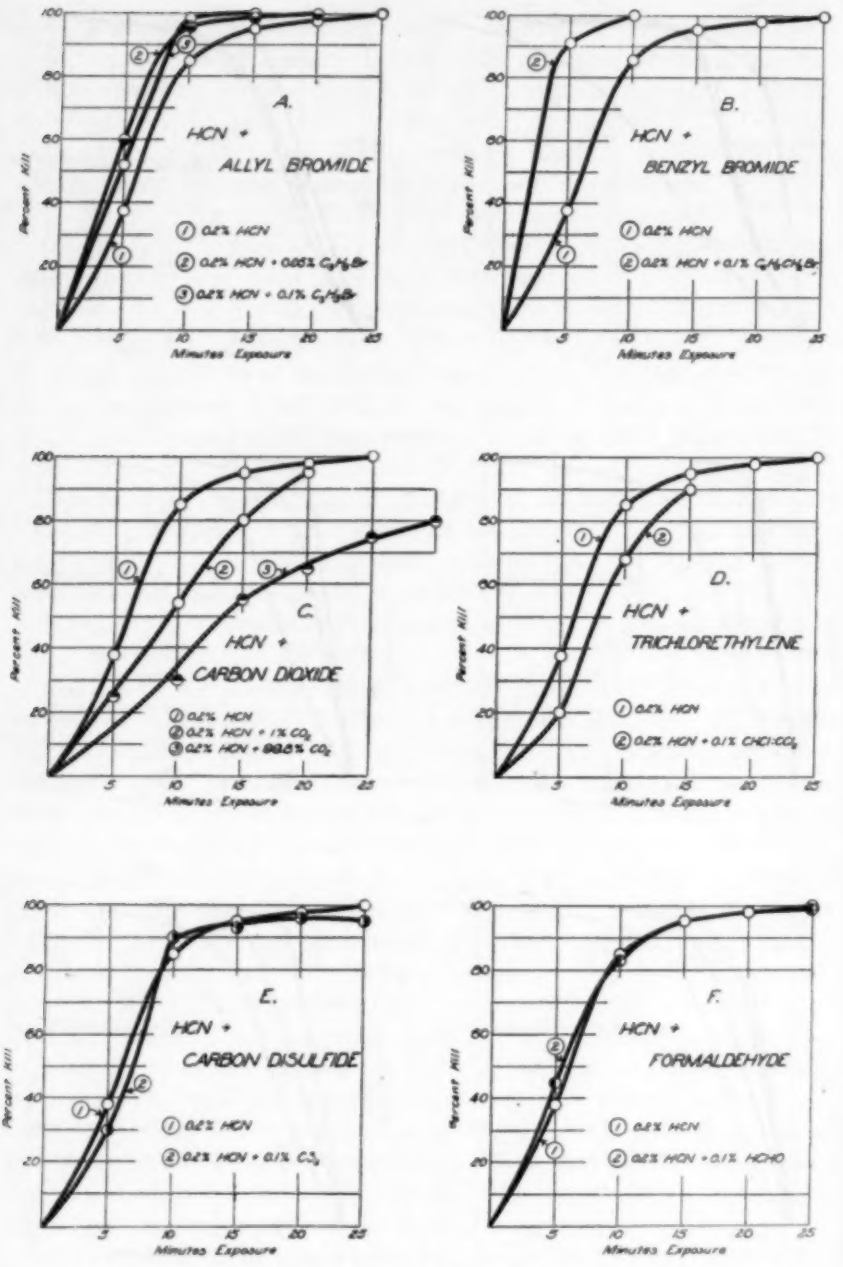


FIG. 88.--Toxicity Curves—Auxiliary Gases with HCN.

by weight so that comparisons were readily made. Unless there was a marked straightening of the curve, showing a reasonably wide divergence from the HCN curve, results were considered as negative. When results showed that 0.1% in air of the auxiliary gas in conjunction with HCN was of value in shortening the time to kill, further experiments were performed using lower concentrations of the auxiliary gas, first 0.05% and later 0.025%. Such tests served a double purpose; first, to indicate the lowest limits of effectiveness of the auxiliary gas and second, to verify the previous results.

*Effective Auxiliary Gases.* Of the 33 compounds which were found to be definitely effective by shortening the required exposure time for HCN to 15 minutes or less, the seven best are as follows, in their order of excellence:

salicyl aldehyde
benzaldehyde
ethyl thiocyanate
allyl iso-thiocyanate
thiophenol
benzyl bromide
perchlor methyl mercaptan

The balance of the compounds showing value are grouped as follows:

Acetates: beta brom ethyl -, amyl -.
Acids, organic: acetic -, pyrogallic -.
Alcohols: methyl -.
Aldehydes: croton -, butyric -, isovaleric -.
Benzene derivatives: benzyl chloride, benzoyl chloride.
Bromides: xylyl -.
Chlorides: (benzyl -, benzoyl -) acetylene tetra -, propylene -.
Chlorohydrin: epichlorhydrin.
Cyanogen: methyl thiocyanate.
Ether: beta naphthyl ethyl -.
Ketone: acetophenone.
Nitrile: phenylacetonitrile
Nitrogen compound: pyridine.
Nitro: chlorpicrin, nitrobenzene.
Sulphur compounds: thiophosgene, methyl sulphate.
Miscellaneous: camphor, pyrethrum powder.

Discussion.—The most effective gases in increasing the toxicity are found to come under the classes referred to under Qualitative Tests as (1) strongly toxic and (2) toxic and irritating, while the half dozen most effective come under the second classification. As an example of the strongly toxic group, cyanogen chloride at 0.10% concentration shortened the time to kill slightly but at 0.05% was of no value (Fig. 87b). In fact this particular compound does not appear under the first thirty-three most effective. Certain of the compounds used in the qualitative tests, such as hydrogen chloride and phosgene were not used in the

toxicity tests for various reasons, as for example extreme toxicity to humans.

Of the seven most effective gases, all used in qualitative tests were markedly irritating to beetles and partially toxic. Of these salicyl aldehyde ranks first, with benzaldehyde a close second. Concerning the question of the comparative toxicity of a given group of compounds of similar structure, this work tends to show that the toxicity increases with the increase in boiling point. Formaldehyde with a boiling point of —21°C. was relatively ineffectual (Fig. 88f), benzaldehyde with a boiling point of 180°C. was the second best (Fig. 87d), and salicyl aldehyde, (Fig. 87c) with a boiling point of 196°C. was outstandingly the best.

With salicyl aldehyde as an example of this second group, it was found that a concentration of 0.10% with HCN shortened the time to obtain a 100% kill to 5 minutes, as did a concentration of 0.05% (Fig. 87c). This was the shortest exposure time on which observations were made. Even at 0.025% concentration 100% kill was obtained in 10 minutes. This was the most outstanding auxiliary gas found, although benzaldehyde was a close second, 100% kill being obtained in 15 minutes at 0.05% concentration with HCN and in 10 minutes at 0.10% (Fig. 87d). Toxicity curves for two other of the more effective gases in this group are shown, Figure 87e showing the effect of thiophenol in shortening the time to obtain a 100% kill to 20 minutes when used at a concentration of 0.05% and to 10 minutes at 0.10%. In Figure 87f toxicity curves for allyl isothiocyanate are shown, where a 100% kill is obtained in 15 minutes at a concentration of 0.01%, and in 10 minutes at 0.05%.

In the third group (non-toxic and irritating) there are some of the more effective auxiliary gases, such as benzyl chloride (Fig. 88a) and xylyl bromide (Fig. 88b) both of which shortened the time to kill 100% considerably when used at 0.10% concentration with HCN.

In the fourth group (stupefying) are some compounds that produced very interesting results. In Fig. 88d is shown the effect on the toxicity curve of adding 0.10% concentration of trichlorethylene to HCN. The combination actually produced poorer results than did HCN alone. A more striking case of this is shown with carbon dioxide (Fig. 88c) where 1% and 10% concentrations were added to HCN. This is of particular interest as it has been suggested by Hazelhoff (4) that $CO_2$ should accelerate the penetration of HCN into the tracheal system of insects and thereby increase its toxic action. Later Cotton and Young (5) showed that $CO_2$ did actually increase the toxicity of certain fumigants to the flour beetles. However in the case of the ladybird beetles it was found that the opposite result was obtained, namely that the use of $CO_2$

actually decreased the toxicity of HCN. These results were, by the way, the first indication of the possibility of there being such a phenomenon as was later described as "Protective Stupefaction" (6, 7).

Two examples from the last group (no effect) will suffice to show the trend of results. Carbon bisulfide (Fig. 88e) and formaldehyde (Fig. 88f) had no effect on the time to kill 100% when used at 0.10% concentration in conjunction with HCN. This might be expected for at even twice this concentration they showed no visible effects on the beetles.

These studies with ladybird beetles provided ample basis for the belief that auxiliary gases could be used to advantage with HCN to provide a distinct additional toxicity. This was, of course, particularly true of salicyl aldehyde, and the additional evidence that both humans and plants seemed quite tolerant to the aldehyde indicated great value for this compound or one of like characteristics. If, or when, these results could be duplicated with scale insects as indices of toxicity, fumigation with hydrocyanic acid would be greatly improved.

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# LABORATORY EXPERIMENTS WITH VARIOUS FUMIGANTS AGAINST THE WIREWORM *LIMONIUS (PHELETES) CALIFORNICUS* MANN[1]

By RUSSELL S. LEHMAN, *Assistant Entomologist, Division of Truck Crop and Garden Insects, U. S. Bureau of Entomology*[2]

ABSTRACT

Thirteen fumigants were tested on the wireworm *Limonius (Pheletes) californicus* Mann., and their median lethal concentrations in air determined under controlled conditions and compared with that of carbon disulfide. The time of exposure to the fumigant was 5 hours in all tests, the concentration being the variable factor. Some wireworms that appeared to be dead 15 days after exposure to carbon disulfide recovered and were able to walk one month after the exposure. The fumigants used ranged from 0.56 to 192.9 times as toxic as carbon disulfide, allyl isothiocyanate being the most toxic.

In order to broaden the program of control work against wireworms in the Pacific Northwest, it was considered desirable to investigate a number of fumigants not heretofore used against these larvae to see if any of them were effective. Since carbon disulfide has been used successfully against wireworms and other insects, it was decided to use this fumigant as a basis for comparison. Laboratory experiments were undertaken first in order to eliminate the less effective fumigants without laborious field work.

In the early work with insect fumigants, most of the investigators, as Moore (3) and Tattersfield and Roberts (8), determined the concentrations necessary to kill 100 per cent of the insects in a fixed period of time; others, as Strand (6), determined the time required to kill 100 per cent at a fixed concentration.

Trevan (9) showed the error introduced when the 100 percent mortality point is taken as a basis for comparison and the desirability of using the 50 per cent mortality point. Strand (7) has very ably reviewed and discussed the 50 per cent point, and the writer (2) has previously used the 50 per cent mortality point as a basis for a comparison of fumigants and found it quite satisfactory.

Tattersfield and Roberts (8), in experiments with various organic compounds against wireworms (*Agriotes*), found, as did the writer, allyl isothiocyanate to be the most toxic compound tested. They listed

[1]Order Coleoptera, family Elateridae.

[2]All the experimental work for this investigation was conducted at the laboratory of the U. S. Bureau of Entomology, located at Walla Walla, Wash., M. C. Lane, in charge.

UNIV OF

Consant Temperature and Humidity Chamber used in the Experiments with Various Fumigants against Wireworms.

allyl isothiocyanate and chloropicrin as being of high toxicity, pyridine of moderate toxicity, and carbon disulfide of low toxicity.

Moore (3), in experiments with 28 benzene derivatives against house flies, found them all to be more toxic than carbon disulfide.

Strand (6), in comparing chloropicrin with carbon disulfide, found that 1 pound of chloropicrin effected a 100 per cent kill of *Tribolium confusum* at 25°C (77°F.), in 2 hours and 15 minutes and that when 2 pounds was used the same kill was obtained in 50 minutes. With 15 pounds of carbon disulfide 1 hour and 1½ hours were required to obtain 100 per cent mortality.

Toxicologists will certainly agree that in comparing fumigants only one factor should be varied. A majority are, no doubt, in favor of keeping the temperature and the humidity constant. Whether the time or the concentration is varied does not appear to the writer to make much difference in the accuracy of the results. Richardson and Haas (4) concluded that the relative toxicity of pyridine and nicotine was approximately the same at all the time-concentration levels tested. In most cases, however, keeping the time constant and varying the concentration would seem to be the most convenient procedure and should give the same results. If a saturated atmosphere of the fumigant is necessary, as used by the writer in 1930 (2), then the time must be varied to get the desired mortality. If one wishes to compare the work of others, an identical method of procedure would be necessary. Strand (7) measured the toxicity of insect fumigants using a constant exposure period of 5 hours and varying the concentration of the fumigant, and the writer has adopted this method. Most of the fumigants used were among those found by Roark and Cotton (5) to be 100 per cent effective against the rice weevil (*Sitophilus oryzae* L.).

MATERIALS AND APPARATUS.—The fumigants tested are listed in Tables 1 and 2. All the compounds were of the highest purity obtainable, and, with the exception of allyl isothiocyanate which was labeled "practical," were of high purity. It was necessary to dissolve several of the fumigants in water or alcohol in order that all the dosages could be measured.

The wireworms (*Limonius* (*Pheletes*) *californicus*) were obtained the preceding spring and summer by baiting with ground wheat.

The experiments were conducted in accurately calibrated 6-liter Erlenmeyer flasks, inside each of which was suspended a 40-mesh copper-wire basket 1 by 1¾ by 4 inches so that it was about 3 or 4 inches from the bottom of the flask. (Plate 49).

These flasks, containing the insects and fumigants, were kept in a

constant temperature and humidity chamber (Fig. 89) similar to those described by Brindley and Richardson (1), equipped with the usual thermoregulator, mercury relay, and electric fan. The light globes,

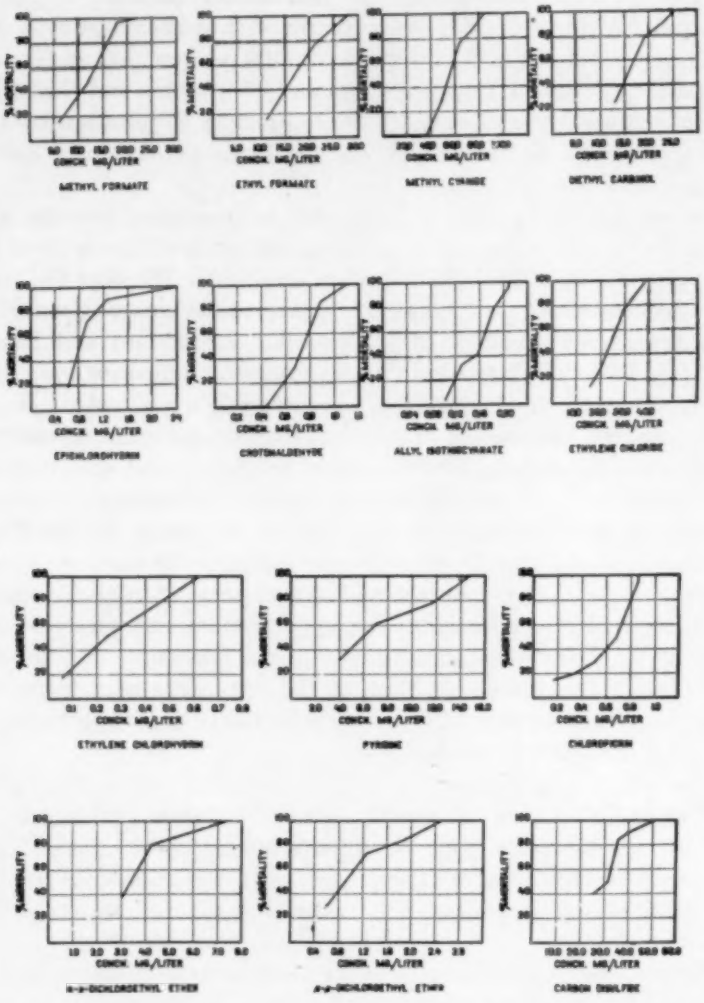



FIG. 89.—Concentration-mortality curves for various fumigants used against wireworms (*Limonius* (*Pheletes*) *californicus*)

which were used as a source of heat, and the inside of the chamber were painted black, and a black cloth was hung over the glass of the door. These precautions were taken so that the wireworms, which are soil-

inhabiting insects, would receive as little light as possible. The chamber was maintained at a temperature of 25° ± 0.1° C., (77° ± 0.18° F.) and at 80 per cent relative humidity.

The lower concentrations of fumigants were measured in a pipette[3] graduated to 0.00033 cc. and the higher concentrations in a pipette graduated to 0.01 cc. The range of concentrations required the use of only one of the pipettes for each fumigant.

PROCEDURE.—Upon removal from the baits the wireworms were kept in outside soil cages until the first of October, when they were placed in containers without food at a temperature of 10° C. (50° F.). The experiments were conducted from October 27, 1932, to March 10, 1933. One week before the wireworms were to be employed in the experiments they were given whole wheat for food and maintained at a temperature of 20° C. (68° F.). After exposure to the fumigants they were returned to the containers with whole wheat for food. As it was important that all the wireworms should be of about the same size and weight, they were weighed several times during the experiments.

In order to condition the air in them, the flasks were placed in the constant temperature and humidity chamber 18 hours before the experiment was begun.

Twenty-five wireworms (100 in case of tests with carbon disulfide and chloropicrin) were put in each basket, the desired concentration of the liquid fumigant was pipetted into the flask, and the basket was suspended within the flask. A loosely fitting rubber stopper was lowered, inverted, into the mouth of the flask to the calibrated mark and the flask sealed with paraffin. Six flasks were placed in the constant temperature and humidity chamber at a time; one of the flasks, containing no fumigant but otherwise treated in the same way, was used as a control.

A uniform exposure period of 5 hours was allowed in all the experiments. At the end of this time the wireworms were removed from the flasks and examined. At this first examination the wireworms were observed for signs of movement but were not touched. Subsequent examinations were made 1, 3, 7, 10, 15, 30, 45, and 60 days after exposure. At each examination after the first the inactive and apparently dead wireworms were prodded with a forceps. A wireworm was considered active if it was able to walk on a flat surface, inactive if able to move but unable to walk, and dead if it did not move when prodded with the forceps. No wireworm was discarded until it had decomposed.

[3]This pipette was furnished by Dr. F. L. Campbell, U. S. Bureau of Entomology, Takoma Park, Md.

The percentage of wireworms killed by the fumigant was then calculated according to the formula previously used by the writer (2), $\frac{x-y}{x} \times 100$ = per cent killed, where $x$ = percentage living among the controls and $y$ = percentage living among those exposed to a fumigant. The examination made 10 days after exposure was used for determining the percentages except in the tests with carbon disulfide and chloropicrin, in which the 15 and 30 day examinations, respectively, were taken.

It was, of course, necessary to conduct a number of preliminary experiments to determine the concentrations of fumigants necessary to obtain mortalities between 0 and 100 per cent.

RESULTS.—The results obtained with the different fumigants in various concentrations are summarized in Table 1 and shown graphically in Fig. 89. The median lethal concentration, or 50 per cent mortality point, for each fumigant has been calculated from the data given in Table 1 and is shown in comparison with the median lethal concentration of carbon disulfide in Table 2.

DISCUSSION.—Until recently most entomologists working with insecticides have failed to state definitely how long after treatment their observations were made, and what was their criterion of death. Biologists have been more exact than entomologists in this regard. When an investigator does not state the time of observation, in this regard. it is assumed to be immediately after exposure. In tests of fumigants a serious error results if observations are not continued for at least several days, or until one can be certain that no further recovery will result.

The writer has selected 10 days after exposure as the time at which a comparison of the fumigants could best be made, as the subsequent examinations showed that, with the exceptions of carbon disulfide and chloropicrin, there was no further recovery after this time. With carbon disulfide, however, observations made 15 days after exposure were considered more accurate, and with chloropicrin it required one month before definite conclusions could be drawn. Actually, however, there was little difference between the percentages dead on these examinations and on the 10-day examination.

The question arises as to whether a control is necessary. Some investigators think not, especially if the natural mortality is slight. Where there is a possibility of a high natural mortality, however, a control is absolutely essential. In the case of wireworms there is that possibility, and 10 days after exposure there may be a range in natural mortality of 0 to 50 per cent among wireworms in different flasks from the same lot obtained from the same field at the same time and kept

under identical conditions. The question also arises, When is a control properly interpreted? If two sets of wireworms are taken, one to serve as a control and the other treated with a fumigant which kills or anesthetizes them, and at the end of 10 days 50 per cent of the treated lot have recovered while in the control 25 per cent have died naturally, is it correct to say that only 75 per cent were treated by the fumigant and that the fumigant killed only 33 per cent? May it not be true that, owing to the effect of the fumigant, there was not the same natural death in the fumigated lot? The wireworms in the fumigated lot did not have normal activity, and therefore natural life for some may have been prolonged. In other words, the fumigant may actually have killed the 50 per cent. This question of how best to use the control in calculating the mortality has perplexed the writer for some time, but for the present the use of the formula indicated appears to be the only logical method to follow.

It was found, as shown by the data in Table 3, that the same concentration of ethylene chlorohydrin in alcoholic solutions of different percentages resulted in a variation in toxicity to the wireworms. In other words, when solutions consisting of various proportions of ethylene chlorohydrin and ethyl alcohol were added to the flasks in such volumes that the quantity of ethylene chlorohydrin per unit volume was the same in each flask, it was found that as the proportion of ethylene chlorohydrin increased in the solution the mortality of the wireworms increased. When distilled water was used to obtain various dilutions of the ethylene chlorohydrin, however, the mortality was practically the same as one would expect with the same concentration.

An adequate explanation of this phenomenon is lacking. There should be no chemical reaction between the two compounds. It was thought at first that the ethyl alcohol might have had an anesthetic effect upon the larvae, reducing the rate of respiration and thus causing less of the ethylene chlorohydrin to enter the body. But since the ethyl alcohol appeared to have little effect upon the larvae in the control, which contained the maximum quantity of ethyl alcohol used in the experiment, it is not likely that an anesthetic effect was produced. The fact that ethyl alcohol was used as a solvent for several other compounds in these experiments without this result also gives discredit to this explanation. The results obtained with ethylene chlorohydrin when not in solution compared favorably with the effect produced when the ethylene chlorohydrin was dissolved in water.

The reaction of the wireworms to chloropicrin was interesting. The gas seemed to affect their nervous systems, since they were able to twist and roll but were unable to walk. Their legs did not appear to be

paralyzed, but they had no control over them. Two months after exposure to chloropicrin the wireworms were still alive but not normal. They did not feed, and they were unable to walk. They never recovered.

The results with carbon disulfide were equally interesting. At a concentration of 39.25 mg. per liter, for example, the wireworms were inactive at the end of the 5-hour exposure period; 24 hours later 17 were inactive and 8 appeared dead; 72 hours after exposure 4 were able to walk, 10 were inactive, and 11 appeared dead; 1 week after exposure 6 were inactive and 19 appeared dead; 10 and 15 days after exposure 3 were inactive and 22 appeared dead; 1 month after exposure 5 were able to walk, 2 were inactive, and 18 appeared dead; and 2 months after exposure 3 were able to walk and 22 were dead and had decomposed. The most remarkable thing here is the fact that at least 2 of those that appeared dead 15 days after exposure were able to walk 15 days later. After such an experience as this in some of the preliminary experiments, none of the larvae were ever called dead until they had decomposed. The writer (2) had a similar experience with paradichlorobenzene. It is the writer's opinion that most investigators of fumigants do not keep the test insects long enough after exposure to determine definitely whether they are actually dead or merely anesthetized.

TABLE 1. MORTALITY OF WIREWORMS RESULTING FROM EXPOSURE FOR 5 HOURS TO VARIOUS CONCENTRATIONS OF DIFFERENT FUMIGANTS AT A TEMPERATURE OF 25°C. (77°F.) AND A RELATIVE HUMIDITY OF 80 PER CENT

| Fumigant | Formula | Concentration of fumigant *Mg.* | Wireworms killed by fumigant* *Per cent* |
|---|---|---|---|
| Carbon disulfide | $CS_2$ | 23.70 | 42.9 ( 41.6) |
| | | 27.74 | 37.1 ( 40.3) |
| | | 31.50 | 50.0 ( 54.6) |
| | | 35.44 | 84.3 ( 87.0) |
| | | 39.50 | 90.0 ( 94.8) |
| | | 43.18 | 100.0 (100.0) |
| | | 47.17 | 97.0 (100.0) |
| | | 51.03 | 100.0 (100.0) |
| | | 54.95 | 100.0 (100.0) |
| | | 59.15 | 100.0 (100.0) |
| Chloropicrin† | $CCl_3NO_2$ | .17 | 15.0 ( 12.5) |
| | | .35 | 20.0 ( 8.3) |
| | | .51 | 30.0 ( 16.7) |
| | | .69 | 50.0 ( 58.3) |
| | | .86 | 95.0 ( 95.8) |
| | | .86 | 100.0 (100.0) |

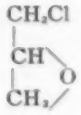
| | | | |
|---|---|---|---|
| Methyl cyanide | $CH_3CN$ | 6.12 | .0 |
| | | 36.70 | .0 |
| | | 48.94 | 28.6 |
| | | 64.22 | 76.2 |
| | | 73.52 | 85.7 |
| | | 85.64 | 100.0 |
| | | 97.88 | 100.0 |
| Allyl isothiocyanate‡ | $CH_2{:}CH.CH_2NCS$ | .10 | 4.2 |
| | | .13 | 33.3 |
| | | .16 | 41.7 |
| | | .18 | 79.2 |
| | | .21 | 95.8 |
| | | .21 | 100.0 |
| | | .24 | 100.0 |
| α, β-Dichloroethyl ether | $CH_2ClCHClOCH_2CH_3$ | 3.04 | 36.4 |
| | | 4.25 | 81.0 |
| | | 6.09 | 91.7 |
| | | 6.76 | 91.7 |
| | | 7.41 | 100.0 |
| Pyridine | $CH(CHCH)_2N$ | 4.03 | 31.9 |
| | | 7.07 | 61.5 |
| | | 8.60 | 79.5 |
| | | 11.60 | 78.1 |
| | | 12.39 | 82.9 |
| | | 13.87 | 97.4 |
| | | 14.63 | 97.4 |
| | | 14.67 | 100.0 |
| Ethylene chlorohydrin§ | $CH_2ClCH_2OH$ | 0.06 | 17.7 |
| | | .25 | 52.4 |
| | | .38 | 81.0 |
| | | .50 | 76.2 |
| | | .63 | 100.0 |
| | | .76 | 100.0 |
| Crotonaldehyde | $CH_3CH=CHCHO$ | .45 | .0 |
| | | .67 | 31.8 |
| | | .89 | 86.4 |
| | | 1.11 | 100.0 |
| | | 1.34 | 100.0 |
| Epichlorohydrin |  | .61 | 19.1 |
| | | .92 | 72.7 |
| | | 1.23 | 90.9 |
| | | 2.44 | 100.0 |
| Ethylene chloride | $CH_2ClCH_2Cl$ | 15.79 | 14.6 |
| | | 19.76 | 26.1 |
| | | 29.65 | 76.2 |
| | | 39.28 | 100.0 |
| Methyl formate | $HCOOCH_3$ | 6.11 | 15.0 |
| | | 12.19 | 47.4 |
| | | 18.34 | 95.8 |
| | | 22.96 | 100.0 |
| | | 27.47 | 100.0 |

TABLE 1—*Concluded*

| Fumigant | Formula | Concentration of fumigant *Mg.* | Wireworms killed by fumigant* *Per cent* |
|---|---|---|---|
| Diethyl carbinol | $(C_2H_5)_2CHOH$ | 12.86 | 26.3 |
| | | 19.10 | 79.0 |
| | | 23.14 | 91.7 |
| | | 25.63 | 100.0 |
| β, β-Dichloroethyl ether | $CH_2ClCH_2OCH_2CH_2Cl$ | .63 | 31.8 |
| | | 1.26 | 73.7 |
| | | 1.88 | 84.2 |
| | | 2.51 | 100.0 |
| Ethyl formate | $HCOOC_2H_5$ | 11.40 | 15.0 |
| | | 17.04 | 52.6 |
| | | 21.14 | 76.2 |
| | | 25.52 | 95.2 |
| | | 28.31 | 100.0 |

*The mortality percentages were calculated from the number of dead wireworms observed 10 days after exposure except in the tests with carbon disulfide, when the 15-day exposure was used, and with chloropicrin, when the 30-day exposure was used. The numbers given in parentheses in the cases of the tests with these two fumigants are the apparent mortalities obtained at the 10-day exposure.

†10 per cent solution in ethyl alcohol.

‡5 per cent solution in ethyl alcohol.

§10 per cent solution in water.

Some of the fumigants that are shown in this investigation to be much more effective against wireworms than carbon disulfide in air have proved less effective in soil. This subject will be dealt with in a later publication.

TABLE 2. MEDIAN LETHAL CONCENTRATIONS OF THE VARIOUS FUMIGANTS AND THEIR TOXICITY COMPARED WITH THAT OF CARBON DISULFIDE

| Fumigant | Median lethal concentration *Mg./liter* | Relative toxicity ($CS_2=1$) |
|---|---|---|
| Carbon disulfide | 31.50 | 1.0 |
| Methyl cyanide | 55.82 | .56 |
| Ethylene chloride | 24.48 | 1.3 |
| Ethyl formate | 16.65 | 1.9 |
| Diethyl carbinol | 15.67 | 2.0 |
| Methyl formate | 12.52 | 2.5 |
| Pyridine | 5.89 | 5.3 |
| α, β-Dichloroethyl ether | 3.41 | 9.2 |
| β, β-Dichloroethyl ether | .90 | 35.0 |
| Epichlorohydrin | .79 | 39.8 |
| Crotonaldehyde | .74 | 42.4 |
| Chloropicrin | .69 | 45.9 |
| Ethylene chlorohydrin | .24 | 131.9 |
| Allyl isothiocyanate | .16 | 192.9 |

TABLE 3. MORTALITY OF WIREWORMS FOLLOWING TREATMENT WITH VARIOUS PERCENTAGES OF ETHYLENE CHLOROHYDRIN IN ETHYL ALCOHOL AND IN WATER, THE CONCENTRATION OF ETHYLENE CHLOROHYDRIN BEING CONSTANT AT 0.626 MG. PER LITER

| Solvent | Ethylene chlorohydrin in solvent *Per cent* | Wireworms killed *Per cent* |
|---|---|---|
| Ethyl alcohol | 5 | 19.3 |
| | 10 | 25.0 |
| | 15 | 30.0 |
| | 20 | 35.0 |
| | 25 | 52.6 |
| | 30 | 73.7 |
| | 35 | 52.6 |
| | 40 | 68.4 |
| Distilled water | 5 | 90.9 |
| | 10 | 85.0 |
| | 15 | 100.0 |
| | 20 | 86.4 |
| | 25 | 100.0 |
| | 30 | 100.0 |
| None | — | 84.2 |
| | — | 90.0 |
| | — | 95.0 |
| | — | 86.4 |
| | — | 95.5 |

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# AIRPLANE LIQUID SPRAYING

By FRANK B. HERBERT, *Entomologist, Balfour, Guthrie and Co., Ltd., San Francisco, Cal.*

ABSTRACT

A report on the latest method of applying liquid sprays by airplane. A discussion of types of insecticides and fungicides used, methods of applying, speed, results, advantages, etc. Illustrations.

A new and novel method of applying liquid insecticides and fungicides has been found in the use of airplanes. Although first tried but a year and a half ago this method of application has proven that it undoubtedly has a place in modern science.

Two companies have patented applicators and have treated a total of more than two thousand acres of various crops with satisfaction.

HISTORY OF DEVELOPMENT.—The Hawke Crop Dusting Company was the first to develop a liquid applicator for airplanes. In this they used the exhaust of the motor to break up and distribute the spray, but this was not satisfactory and was abandoned as its volume was too small and the heat was dangerous.

Next the Independent Crop Dusting Company invented a steel bristle rotary brush driven by a small propeller. The spray oil flowed by gravity to the center of the brush, centrifugal pumps forcing it out through spacers to the bristles which upon rotating broke the material into a fine fog. See Plate 51, Figure 1.

In the meantime the Hawke Company had invented another type which used propeller blades instead of brushes. The material flowed by gravity into the hollow three bladed propellers and through jets set in small venturi tubes near the tips of the blades. Between the centrifugal force and the speed of the propellers this device also broke the oil into a fine fog. See Plate 51, Figure 2.

Both types of "rotors" are now in use and have proven very satisfactory.

METHOD OF APPLICATION.—The concentrated oil is applied using air as a carrier instead of water. The oil is made miscible so that it will not be repelled by the moisture it may contact and to give greater creeping power.

Oils seem to be essential as water solutions evaporate before contacting the plants. These oils may be used for scale control or may carry other insecticides such as nicotine or pyrethrum or oil soluble fungicides.

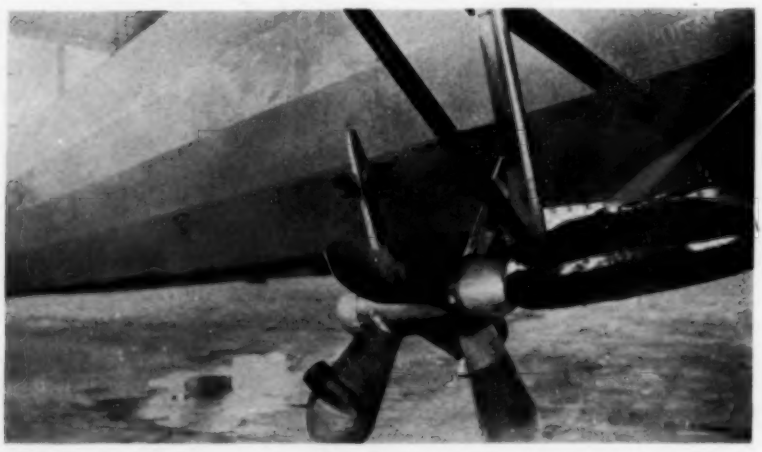
CAPACITY.—The planes travel from 80 to 110 miles per hour and the rotors are capable of throwing out the spray at the rate of 5 to 80 or 100 gallons per minute, depending upon the amount required.

1—Hawke Crop Dusting Company plane applying Dormant Soluble Oil on apricots for scale control on the L. S. Lantz orchard at San Jose, California.

2—Planes loading Nicona for Peach Twig Borer Control on the Marsh Ranch at Brentwood, California. *All photos by Author*

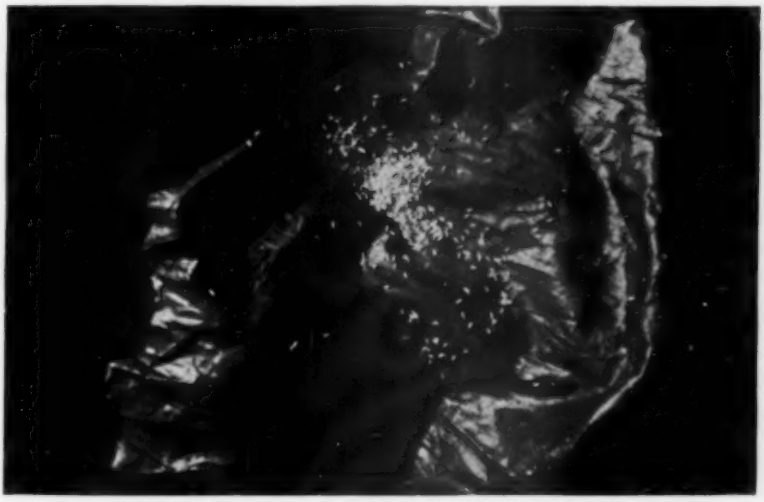
Plate 51

1—The Independent Crop Dusting Company's "rotor." There is one on each lower wing of the plane.



2—The Hawke Crop Dusting Company's "rotor." The plane is equipped with two "rotors," each connected to the struts under each wing.

1—Plane applying Vapona for grape Leafhopper control on American Seedless Vineyard at Del Rey, California.



2—Leafhoppers from half a vine, knocked down and killed by the above treatment.

Plate 53

1—Plane carrying Vapona for control of onion thrips on onions at Waldo Rohnert Seed Company's Ranch, Walnut Grove, California.

2—Plane applying Miscible Nicona for pear thrips on prunes on G. C. Bouret orchard, San Jose, California.

The planes are able to distribute from 2 to 15 gallons per acre so evenly that there is little danger due to too much material concentrating in any one spot. From four to ten gallons are normally required per acre.

In orchard practice the plane usually sprays one row at a time. With vineyards or truck crops they cover a width of 30 to 40 feet at each trip. With either type of crop the plane flies at a height of 2 to 4 feet above the top of the plants, occasionally touching those that stand above the others.

TIME REQUIRED.—Individual acres have been covered in seven seconds, while single loads, which usually consist of 100 to 110 gallons, have been sprayed out in 11 to 20 minutes, covering 15 to 20 acres. Taking into account loading, each plane can apply the spray on 35 to 60 acres per hour. Loading is usually done in about 2 minutes, using rotary pumps driven by auto motors or batteries. These throw 50 to 60 gallons per minute.

COVERAGE.—The oil is broken into a fine fog floating in the air similar to dust. It floats downward as the plane compresses the air below it and then rebounds while the wash of the plane starts it rolling. The material can be seen spreading laterally for 40 to 75 feet from the center of the plane.

The trees or plants receive a heavier film of oil on the upper surface but many tiny droplets of oil can be found on the lower surface if examined microscopically. These slowly diffuse to give a satisfactory coverage. The oil on the upper surface of the twigs and branches creeps around them to aid in coverage.

ADVANTAGES.—Spraying by plane has the following advantages:

*Speed*. Large acreages can be covered at the right time giving better control. Many pests such as brown rot, scab, leaf curl, leaf hoppers, thrips and aphids require treatment within a short period of time.

*Wet ground*. Irrigation checks may be left up, the ground may be wet or irrigation may be under way while airplanes are applying the spray. The ground is not packed by heavy equipment.

*Ground Cover*. Many crops like onions, peas, beans, cotton and melons cover the ground so that any equipment except airplanes would ruin a considerable portion of the crop.

*Materials more potent*. The sprays, especially nicotine and pyrethrum are much more potent in the concentrate form as applied by planes.

*No loss from wind*. Oils when once applied to a surface will not be blown off by wind as is the case with many of the dusts.

*Less Equipment.* Large ranches find it costly to maintain spray equipment and rolling stock to treat their crops at the proper time. By hiring planes there is a considerable saving. Planes can compete economically with most ground equipment.

LIMITATIONS.—Planes are handicapped by windy weather more so than ground equipment, although this is made up for by the greater speed of the plane. In one hour a plane can cover as much ground as a spray rig can in 2 to 4 days.

There is still some question as to whether a plane can cover trees with heavy foliage such as citrus.

COSTS.—Materials applied by plane are generally of higher grade than those applied from the ground, hence cost a trifle more per gallon. This is often offset by the fact that the plane applies a smaller gallonage per acre.

The cost of application for most acreages is 30 cents per gallon. This is reduced to 25 cents for runs a mile or more long. This is cheaper than most ground work in spite of the present low cost of labor.

PESTS TREATED.—Table No. 1 gives a list of many of the pests treated by plane.

TABLE 1. PESTS TREATED BY AIRPLANE

| Pest | Host plant | Acres treated | Material used | Gals. per acre |
|---|---|---|---|---|
| Bud Mite | Pears | 5 | Dormant Soluble Oil-Tox | 10 |
| Peach Blight | Peaches | 364 | Miscible Coprol | 6 |
| | Nectarines | 17 | Miscible Coprol | 6 |
| Shot Hole Fungus | Apricots | 10 | Coprol | 8 |
| Brown Apricot Scale | Apricots | 20 | Dormant Soluble Oil | 6 to 10 |
| Brown Apricot Scale<br>Twig Borer<br>Brown Rot | Apricots | 16 | Coprol No. 2 | 5 to 9 |
| Brown Apricot Scale | Prunes | 20 | Dormant Soluble Oil | 10 |
| Peach leaf curl<br>Twig borer | Peaches | 120 | Coprol No. 2 | 6 |
| Brown Rot<br>Twig borer | Apricots | 10 | Coprol No. 2 | 6 |
| Twig borer | Peaches | 43 | Nicona No. 2 | 6 |
| | | 159 | Arsona No. 2 | 6 |
| | Nectarines | 39 | Nicona No. 2 | 6 |
| Pear Thrips | Prunes | 280 | Miscible Nicona | 5 to 7 |
| Calico Scale | Walnuts | 17 | Dormant Soluble Oil | 9 to 18 |
| Pear Scab | Pears | 50 | Miscible Funjona | 8 |
| Leaf Roller<br>Twig Borer | Apricots | 106<br>85 | Nicona No. 2<br>Arsona No. 2 | 7–8<br>6–8 |

MATERIALS REQUIRED.—In explanation of the materials used, Dormant Soluble Oil is a winter type Miscible Oil. Dormant Soluble Oil

Tox contains certain toxics which aid in penetration and kill of bud mites, armored scale insects, etc.

Miscible Coprol and Miscible Funjona are winter and summer forms of oils containing fungicides. Coprol No. 2 differs in also containing an arsenical.

Miscible Nicona is a miscible summer oil containing nicotine. Nicona No. 2. also contains an arsenical. Arsona No. 2. is a summer oil containing basic lead arsenate. Vapona contains pyrethrum and nicotine in light oil.

Airplane spraying requires many materials and combinations for the control of various pests. As the planes contain no agitators these combinations can not be mixed in the field, but must be combined in the factory so as to assure satisfactory solutions or suspensions. Balfour, Guthrie & Co. is the first manufacturer to design and register materials especially for airplanes. Most of these are also satisfactory for ground machines.

RESULTS.—There was some variation in the control obtained, but the results were far above all expectations. They were fully as satisfactory as ground application. The fungicides applied in the fall not only controlled peach blight but leaf curl as well. The Coprol applied to apricots for shot hole fungus also killed leaf roller eggs.

The Miscible oil applied on prunes and apricots during the dormant season for brown apricot scale showed almost 100 per cent control. This is proof of coverage as all of these scales are found along the under side of the twigs. Several days after application one could lift up the dying scales and find them sitting in a ring of oil.

Thrips control was highly satisfactory. One grower reports that not a single prune was scarred this year, while he sorted out many that were scarred last year. Many of his neighbors are now having to spray for mealy plum lice while none have appeared on his 60 acre orchard to date, this having been a serious problem with him last season.

The control of brown apricot scale with oil and nicotine when spraying for thrips, appears so complete that several growers already plan to leave out their winter scale spray next season and depend on the thrips spray only.

The grape leaf hopper overwintering adults were nicely controlled on the vines by airplane using 4 gallons of Vapona per acre. This will have to be increased slightly for nymphs to be sprayed in June to account for the extra foliage.

POSSIBILITIES.—The results to date indicate that there are many pests that can be satisfactorily controlled by the use of airplanes, many

of them better than with ground machines. As crops become of greater value, still greater interest will be shown in this type of spraying. Growers with large acreages are already finding the plane of great use, especially during wet seasons.

Epidemics where speed is the essential requirement will find planes bearing the brunt of the battle.

Preliminary work is now being done on onions for onion thrips, which indicates they will be controlled by plane more satisfactorily than with any other method.

## A PRACTICAL TEST OF CHEMICALLY TREATED BANDS FOR THE CONTROL OF THE CODLING MOTH

By E. J. NEWCOMER, A. R. ROLFS, and F. P. DEAN, *U. S. Bureau of Entomology*

ABSTRACT

Chemically treated bands were tested during three successive seasons. In spite of severe infestations, the increase in the wormy (*Carpocapsa pomonella* L.) fruit was only 72.5 per cent in the banded block, as compared with 204 per cent in two blocks not banded but sprayed the same. It was estimated that an average of about 50 per cent of the worms leaving the fruit were caught in the bands.

A great deal of experimental work has been done with bands treated with various chemicals for killing the larvae of the codling moth (*Carpocapsa pomonella* L.). There have been many papers published giving results in terms of relative numbers of larvae caught, and percentages of larvae killed. These results have shown that treated bands are fully as attractive to the larvae as untreated bands, and that the chemicals used are, for the most part, extremely effective in killing the larvae. The writers have not been able to find any publication giving the practical results of banding, in terms of percentage of wormy or of sound fruit, and it is the purpose of this paper to present data of this nature.

In 1930 a rather wormy orchard was selected for spraying experiments, in the Yakima Valley of Washington. This orchard consisted of alternate double rows of rather large Jonathan and Winesap apple trees. A dozen or more different spraying treatments were outlined, and four of these were chosen, each of which was to be used in four different places in the orchard. Accordingly, four blocks of 64 trees each were chosen, each block being divided into smaller blocks of 16 trees, and one of the four treatments was used in each of these four smaller blocks. There were thus 16 subplats, each of which contained both varieties of apples.

The schedule included a calyx spray and six cover sprays, and the treatments were as follows:

1. Lead arsenate, 2 or 3 pounds to 100 gallons.
2. Lead arsenate, plus three-fourths of 1 per cent mineral oil emulsion in 2 sprays.
3. Lead arsenate, 5 sprays; nicotine sulfate, 1–1,200, plus three-fourths of 1 per cent mineral oil emulsion, for the last 2 sprays.
4. Lead arsenate, first 2 sprays; followed by barium fluosilicate or cryolite used with fish oil or mineral oil emulsion.

This schedule was adhered to for three seasons, and while there was some variation in treatment from season to season, there was no variation in the different subplats in a single season.

One block of 64 trees, including all four treatments, was banded annually for the three seasons. This will be called the B block. Blocks A and C were not banded at all, and block D was not banded in 1930 or 1931, but the trees were scraped in the fall of 1931 and banded in June 1932. All banded trees were thoroughly scraped, and bands treated with the usual mixture of beta naphthol and oil were used. Fresh bands were applied each year. No injury to the trees from the use of these bands was noted.

In order to learn the effect of this banding, all of the fruit from 16 trees in each block of 64 trees was examined each season. This included 4 trees, two of each variety, in each of the 16 subplats. Over 100,000 apples from the 64 trees were examined each year. The results of this examination are shown in the following table:

| Blocks | Treatment | Apples wormy (Per cent) 1930 | 1931 | 1932 | * Increase over 1930 (Per cent) 1931 | 1932 |
|---|---|---|---|---|---|---|
| B | Banded 3 years | 11.6 | 12.8 | 20.0 | 10.4 | 72.5 |
| D | Banded in 1932 only | 13.0 | 27.7 | 30.2 | 113.0 | 132.0 |
| A & C | Not banded | 11.0 | 22.5 | 33.5 | 105.0 | 204.0 |

The seasons of 1931 and 1932 were extremely favorable to the development of the codling moth, and there was a general increase in infestation throughout the State. In blocks A and C, in spite of a heavy spray schedule, the percentage of wormy fruit had more than tripled in the three years. In the banded block B, on the other hand, the percentage in 1932 had shown an increase of only 72.5 per cent over 1930. In block D the increase in 1931 was somewhat greater than in blocks A and C, being 113 per cent as compared with 105 per cent. This block was banded in 1932, and at the end of the season it showed an increase of only 132 per cent over 1930, as compared with 204 per cent in the blocks

not banded. It was actually less wormy than the unbanded blocks in 1932, although it had been wormier in 1931.

These results show quite conclusively that banding is a very valuable adjunct to the usual spraying treatment. Each of the banded blocks, B and D, had an area of only about one acre, and the writers believe that if a larger area had been banded, the results would have been even more striking.

In order to find out what proportion of the larvae were caught in the bands, records were made in 1931 and 1932 of the number of larvae that had left the fruit on certain banded trees at the time the fruit was picked and removed from the orchard. This number was compared with the number of larvae found in the bands on those trees. In 1931 the fruit from 7 trees was examined, and of 465 larvae that had left the apples, 156, or 33.5 per cent, were in the bands. In 1932 the fruit of 15 trees was examined, and of 961 larvae that had left the apples, 654, or 68 per cent, were in the bands. The percentage will undoubtedly vary considerably, owing to differences in the thoroughness of scraping the trees, differences in the trees themselves, in the time of picking, and in the promptness of removing fruit from the orchard, but it may be assumed from the above figures that approximately 50 per cent of the larvae leaving the apples should be caught in the bands.

Incidentally, it was found that only about 20 per cent of the larvae had left the apples when the Jonathans were picked in September, and 35 per cent when the Winesaps were picked in October. This indicates the very great desirability of prompt removal of all apples from the orchard when picked, and the prompt use or destruction of all wormy apples.

## SOME NOTES ON THE BIOLOGY OF THE PEA WEEVIL *BRUCHUS PISORUM* L. (COLEOPTERA, BRUCHIDAE) AT MOSCOW, IDAHO

By T. A. BRINDLEY, *Assistant Entomologist, Bureau of Entomology, United States Department of Agriculture*

ABSTRACT

The hibernation, egg deposition, life cycle, and the length of life of the pea weevil are discussed.

Recent experiments on the control of the pea weevil, *Bruchus pisorum* L., have necessitated additional work on the biology of this pest. In the course of these studies some additional information, not now contained

in the literature concerning the insect, and some which seems to add to that already existing, was accumulated. This information is presented here.

HIBERNATION.—The weevil has been variously reported as spending the winter in the peas (1), in rubbish and out buildings (4), and in lichens and under the bark of several kinds of trees (2). In this part of the country all the individuals that can escape from the peas seek shelter under the bark of pine trees, in old buildings, and in the debris on and about the pea fields.

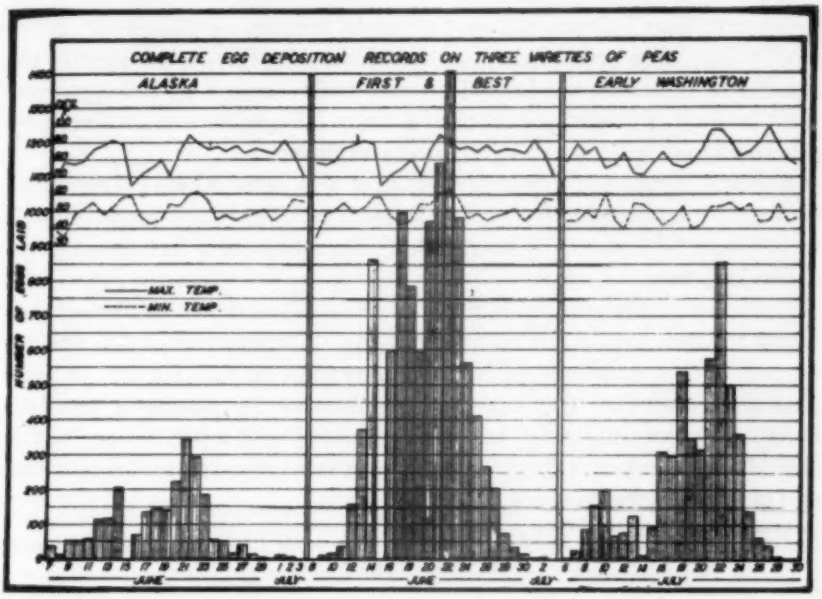



Fig. 90.—Complete records of egg deposition by pea weevils on three varieties of peas.

The shelter afforded by the trash and debris on the pea field after harvest was especially interesting. Eight individuals were collected in a cage covering 12 square feet of a field's surface, and a like number might have been taken elsewhere on the field, for the cage was put out in the spring and was located by chance. Such a survival under the refuse on the field may account for the large populations of pea weevils which appear each spring in certain areas about Moscow, Idaho.

The weevils emerge from hibernation about the time the peas bloom, but they do not appear on the vines in large numbers until shortly after blooming begins. On one patch of volunteer peas which was in blossom

on June 5, 1932, seven weevils were collected in 100 sweeps with a 15-inch collecting net. Five days later, however, 1,096 weevils were collected on the same peas in an equal number of sweeps.

OVIPOSITION.—The insects, after locating the pea vines, feed for about a week on the pollen of the pea flower, after which the weevils mate and lay eggs. Pollen food of some kind is necessary before the weevils are able to lay eggs. The small, bright orange colored eggs are laid on pods of all sizes, varying from those still covered by the corolla of the pea to those that have begun to harden. Pods which have nearly reached their maximum size but are still succulent are preferred. The number of eggs laid on each pod depends, largely, on the extent of the infestation. The greater the number of weevils present, the greater the number of eggs that will be laid on each pod. As high as 126 eggs have been laid on a single pod in this district. Eggs have been found on practically every part of the pea pod and flower.

A study of the egg deposition on over 750 pods showed them to be suitable for oviposition for as long as 18 days. Pea plantings as a whole were found to have pods suitable for oviposition for a maximum of 25 days (**Fig. 90**).

Contrary to the results of other workers (1) and (3), the insect was found to lay a very large number of eggs. A maximum of 735 was recorded, with a minimum of 92 and an average of 432, for the 12 pairs studied (Table 1). The records were obtained by placing a fertilized female in a test tube which had been provided with a pod for egg laying and blooms for food. Each day the eggs were counted and a new pod and blossoms were provided.

TABLE 1. SUMMARY OF THE DAILY EGG DEPOSITION OF 12 PAIRS OF PEA WEEVILS, AT MOSCOW, IDAHO, 1932

| | Number of eggs laid | Deposition period in days |
|---|---|---|
| Maximum | 735 | 84 |
| Minimum | 92 | 21 |
| Average | 432 | 56 |
| Maximum for 1 day | 56 | 1 |
| Minimum for 1 day | 0 | 1 |

LIFE CYCLE.—When the egg of the pea weevil hatches, the young larva bores directly through the chorion of the egg at the point where it is attached to the pea pod into the pod, and then into the pea. Often the weevil does not make its way directly into the seed, but mines about in the wall of the pod before entering the interior and penetrating a seed. Several larvae often enter the same seed, but only one adult has been observed to emerge. Many cases have been observed where two insects

have reached the adult stage, but only one emerges alive, for the slower developing individual, while it is still in the larval stage, kills the first formed adult. Table 2 shows the development of the larvae by instars, as found by splitting infested peas at 2-day intervals throughout the larval period.

TABLE 2. DEVELOPMENT OF THE LARVAE OF THE PEA WEEVIL BY INSTARS AT MOSCOW, IDAHO (1932)

| Date | Number of larvae of each instar | | | | Daily head-capsule measurements in mm. | | |
|---|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | Average | Maximum | Minimum |
| June 28 | 25 | | | | 0.1367 | 0.1430 | 0.1287 |
| 30 | 25 | | | | .1338 | .1430 | .1287 |
| July 2 | 25 | | | | .1436 | .1716 | .1287 |
| 4 | 25 | | | | .1493 | .1573 | .1287 |
| 6 | 24 | 1 | | | .1468 | .1573 | .1287 |
| 8 | 25 | 0 | | | .1578 | .3718 | .1287 |
| 10 | 14 | 11 | | | .2593 | .3888 | .1287 |
| 12 | 2 | 21 | 2 | | .3512 | .3861 | .1287 |
| 14 | 8 | 15 | 2 | | .2938 | .6480 | .1287 |
| 16 | | 9 | 16 | | .5189 | .6578 | .3146 |
| 18 | | 7 | 18 | | .5472 | .6768 | .3024 |
| 20 | | | 25 | | .6395 | .6730 | .6006 |
| 22 | | | 25 | | .6581 | .6912 | .6048 |
| 24 | | | 24 | 1 | .6484 | .9370 | .5863 |
| 26 | | | 25 | 0 | .6470 | .7668 | .6336 |
| 28 | | | 25 | 0 | .6412 | .7150 | .5720 |
| 30 | | | 19 | 6 | .6973 | 1.0224 | .5904 |
| Aug. 1 | | | 11 | 14 | .8107 | 1.0224 | .5720 |
| 3 | | | 15 | 10 | .7410 | .9798 | .5328 |
| 5 | | | 12 | 13 | .7774 | .9372 | .5472 |
| 7 | | | 7 | 18 | .8313 | .9372 | .5900 |
| 9 | | | 3 | 22 | .8724 | 1.0224 | .5964 |

Average head-capsule measurements—first instar, 0.1420 mm.; second instar, 0.3458 mm.; third instar, 0.6353 mm.; fourth instar, 0.9125 mm.

Table 3 gives a summary of the length of the different stages in the life cycle of the insect. These data were obtained by splitting peas at 2-day intervals.

TABLE 3. SUMMARY OF LIFE-HISTORY DATA ON 400 PEA WEEVILS REARED IN FIRST AND BEST PEAS AT MOSCOW, IDAHO, 1932

| Stages | Length of the stages (in days) | | | | |
|---|---|---|---|---|---|
| | Maximum | Minimum | Average | Standard deviation | Modal class |
| Egg | 13 | 6 | 8.7 | 1.46 | 9 |
| Larva | 56 | 28 | 41.7 | 3.48 | 41 |
| Pupa | 18 | 10 | 13.7 | 1.07 | 14 |
| Life cycle | 82 | 50 | 64.1 | 4.04 | 65 |

In the fall, when the peas are ripe, the adults emerge and seek hibernation quarters. Fig. 91 shows the development of the pea weevil and its

relation to temperature and rainfall. The emergence of the weevils in the fall proceeds gradually until a rain, after which they emerge in large numbers.

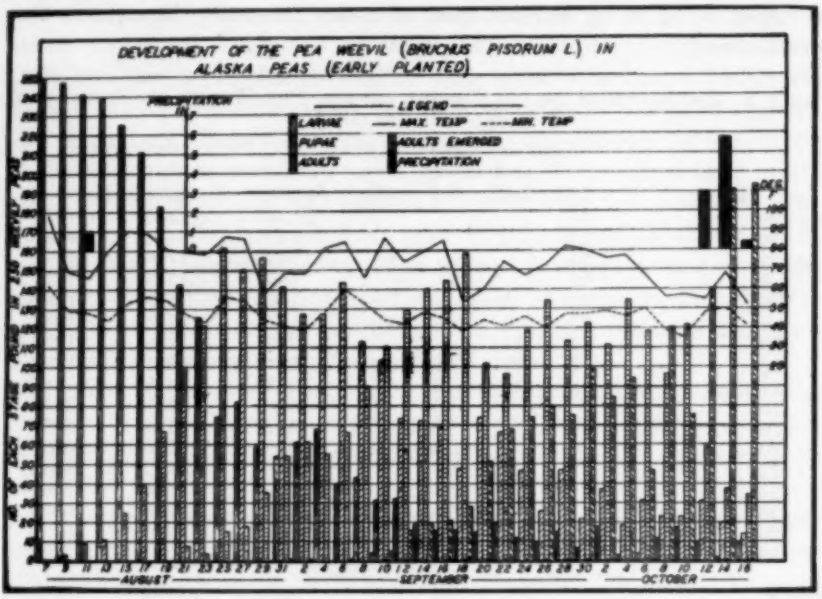



Fig. 91.—Development of the pea weevil (*Bruchus pisorum*) in Alaska peas in 1932.

Length of Life.—The length of life of the insect is much greater than any reported in the literature. On May 28, 1933, 11 per cent of the weevils in the peas of the 1931 crop were still alive. It seems entirely possible that some of these individuals will produce eggs this crop season.

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# THE LOCAL DISPERSAL OF THE PEA WEEVIL

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ABSTRACT

Pea weevil (*Bruchus pisorum* L.) infestation varies greatly in different parts of the same field; the greatest number of adult weevils and the heaviest infestations of the growing peas are usually found on the edge nearest the source of infestation, near hibernation quarters, and in the hollows and swales.

The habits of the adult pea weevil (*Bruchus pisorum* L.) in connection with its dispersal offer an interesting problem, the solution of which may suggest a possible means of control. A study of the dispersal of the pea weevil must of necessity include the sources from which it escapes as well as its methods of overwintering and of reaching the new crop.

This insect has only one known host plant, but this one host, the many varieties of peas, provides several sources from which the weevils may escape. These sources are: (1) seed peas which are imported without proper fumigation, (2) peas left on the vines after the main crop has been harvested, (3) peas which, because of disease or other unfavorable conditions, have been left unharvested, (4) peas which have been grown for hay, (5) volunteer peas which are not harvested, (6) the main crop of peas improperly fumigated or not fumigated at all, (7) screenings cleaned from the main crop of peas, and (8) all peas wasted in the process of harvesting and cleaning the crop. A program of control should consider all of these sources. The importance of some of these sources has been pointed out in an earlier paper (2).

The pea weevil has only one generation a year and spends the winter in the adult stage, either within the pea or in some other suitable place. Soon after the peas are ripe the earliest maturing weevils emerge from them. Other weevils emerge during the next few weeks, or, if the peas are not disturbed, may remain in a semi-dormant condition within the peas during the entire winter or longer. Those weevils which remain within the peas can be easily destroyed, but those which escape cause the greatest problem. It has been pointed out (2) that more than a million pea weevils may be liberated from the shattered peas lost in harvesting one acre of Austrian winter field peas.

The weevils which emerge in the fall fly about during the warm part of the day until they find suitable hibernating quarters. Shortly after harvest the weevils in badly infested fields can be seen flying about in all directions. When the temperature drops in the evening the weevils seek shelter in straw or rubbish on the ground, if they have not already found

more favorable locations. Flights occur day after day until a suitable hibernating place is found. Their search for winter quarters is hastened by rainstorms which cause most of the weevils remaining in the peas on the ground to emerge and seek shelter.

It is not known just how far the pea weevil can fly but observations indicate that it probably can travel several miles. Korab (1) liberated marked weevils in the spring and later found several of them on peas more than two miles away. The outskirts of a town and a large area of wooded land lay between the point of liberation and the point at which they were recaptured. Five counts made by the writers in different places on one field indicated that it was about 80% infested, yet this was the first year that field peas had been raised in this neighborhood. The only accountable source of infestation was from a field a mile away and from another more than two miles away on which peas had been grown the year before.

The weevil hibernates in cracks in fence posts, under the bark of trees, in moss and lichens on trees, in the pine duff under pine trees, and in numerous other places. Hibernation of the pea weevil has been discussed in an earlier paper (3).

The writers have been collecting insects from flight traps in various parts of the Willamette Valley of Oregon over a period of two years. During this time pea weevils have been collected from these traps in every month of the year, but not in all the months of either year. This shows that in Oregon they fly to some extent during warm periods in winter. In Northern Idaho, where the winters are colder, we have not found that they fly during warm periods.

After a few warm days in spring the weevils fly from their shelters and alight on weeds and grasses about their hibernating quarters. They may often be found hiding between a grass blade and leaf sheath. A little later they migrate to the pea fields. Some peas were examined on the afternoon of April 28, 1932 but no weevils were found, although they were numerous on some grasses not far away. By noon of the day following, however, many of them had migrated to these peas.

In badly infested areas the casual observer might fail to see the weevils in a field of peas just beginning to bloom, but a more careful examination would reveal many of them hiding between partly developed leaves. Later, as the weather becomes warm and the flowers appear, the weevils may be seen making short flights from blossom to blossom, or they may be found hiding inside the pea flowers or crawling actively about over the vines. On cold days they remain in hiding within the blooms or within the partly opening leaf buds.

The number of pea weevils may vary greatly in the different parts of the same field. They usually occur in greatest numbers nearest the source of infestation. This was shown very strikingly by sweeping around the edge of a 48-acre field of blossoming peas. The north and west sides of this field adjoined open fields and along these sides an average of 13 weevils and of 50 weevils, respectively, were obtained per 100 sweeps of a collecting net. The south and east sides jogged irregularly, almost forming the hypotenuse of a right-angled triangle. This long, irregular side adjoined a heavy growth of forest trees at one end and trees and a barnyard at the other. Along this side an average of 550 weevils were collected per 100 sweeps. This field had produced a crop of peas the preceeding year and the weevils which had emerged from the shattered peas left on the field had found an abundance of hibernating quarters in the adjoining trees.

In Western Oregon woods adjoin many of the pea fields on all sides. Other fields are bounded by hedges of wild rose and other bushes interspersed with oak, or fir, or other trees which provide shelter for hibernating pea weevils. In such fields the weevils are found most abundantly near the edges. As an illustration of this unequal distribution, sweepings were made about a thirty acre field of blossoming peas, 1240 in going around the edge of the field and an equal number of sweeps 40 to 60 feet in from the edge. 475 weevils were collected; 81 out in the field a short distance, and 394, or nearly five times as many, along the edge.

Table 1 presents a study of the weevil population in a 25-acre field of

TABLE 1. WEEVIL POPULATION AND INFESTATION STUDIES ON AN EARLY PLANTED FIELD

| | Date sweepings were made (1) | | | | | | | | | | | | | | Weevil examinations (2) (% weevily) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6/7 | | | 6/10 | | | 6/16 | | | 6/22 | | | 7/1 | | | | |
| | Edge | 50 ft. in | Center | Edge | 50 ft. in | Center | Edge | 50 ft. in | Center | Edge | 50 ft. in | Center | Edge | 50 ft. in | Center | Edge | 50 ft. in | Center |
| | | | | | | ** | | | ** | | | ** | | | ** | | | |
| | 0 | * | * | 51 | 21 | 8 | 162 | 50 | 29 | 82 | 147 | 13 | 0 | 1 | 2 | 63.6 | 71.2 | 6.0 |
| | 0 | | | 12 | 4 | | 302 | 17 | | 144 | 172 | | 0 | 0 | | 74.4 | 55.8 | 3.4 |
| | 0 | | | 6 | 4 | | 555 | 59 | | 573 | 547 | | 16 | 0 | | 78.6 | 76.9 | 7.4 |
| | 0 | | | 15 | 1 | | 412 | 35 | | 257 | 278 | | 14 | 2 | | 85.2 | 57.8 | |
| | 1 | | | 24 | 0 | | 230 | 87 | | 111 | 175 | | 12 | 4 | | 87.8 | 32.9 | |
| | 0 | | | 20 | 0 | | 156 | 39 | | 48 | 100 | | 43 | 0 | | 73.6 | 34.6 | |
| | 0 | | | 65 | 5 | | 156 | 15 | | 68 | 14 | | 3 | 3 | | 69.0 | 12.0 | |
| | 1 | | | 34 | 6 | | 159 | 26 | | 85 | 21 | | 2 | 1 | | 64.2 | 17.4 | |
| Ave. | 1 | | | 28 | 5 | 3 | 267 | 41 | 9 | 171 | 182 | 4 | 11 | 1 | 1 | 74.5 | 44.8 | 5.6 |

(1) Figures indicate the number of weevils per 100 sweeps of a 15″ collecting net.
(2) Five hundred peas examined.
*No sweepings made.
**Three hundred sweeps taken.

Alaska peas at different dates while the peas were developing. Weevils were collected at the edge of the field, 50 feet in from the edge, and at the center. About 28 times as many weevils per 100 sweeps were collected at the edge of the field as were found in the center. This table also shows the per cent of weevil infestation found after harvest in the peas picked up where the collections had been made. The peas at the edge of the field were about 13 times as heavily infested as those in the center of the field.

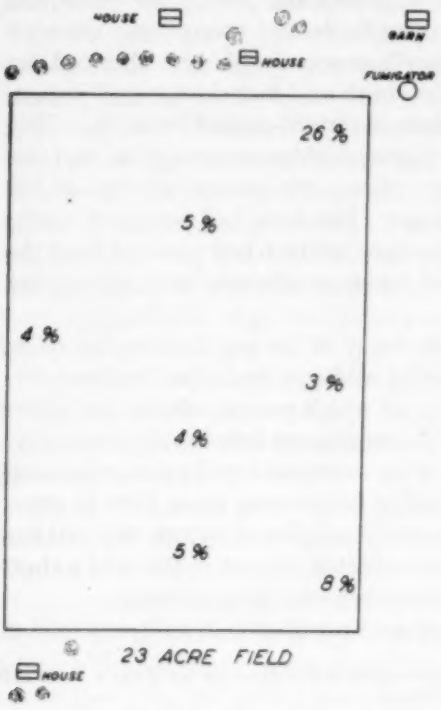


Fig. 92.—Pea weevil infestation in a 23-acre field after harvest.

In the vicinity of Moscow, Idaho, where the pea fields occur on rolling or hilly ground and where hibernation conditions are somewhat different, the greatest number of weevils is generally, but not always, found near the edges of the field. In this section it has been noted that a heavier infestation of weevils is to be found in the swales or hollows than can be found on the ridges or level areas adjoining. Moderate to heavy westerly winds prevail. The pea weevils appear to congregate in the shelter afforded by the low places. In this connection we have found it to be almost invariably true that high points are less infested than low ones. This holds in general without reference to their nearness to the borders of the field.

Table 2 shows the variation in the per cent of weevil infestation found on the hills and in the valleys of one field. The greatest infestation (90%) was in the valley at the edge of the field, while the smallest infestation (12.3%) was on the ridge only 300 feet from the border. The infestation in the valleys was twice as great as the infestation on the ridges.

After harvest the writers have picked up the shattered peas on measured plots in order to get estimates of crop loss and per cent of weevil

infestation. The samples thus collected have invariably shown an uneven distribution of infestation.

TABLE 2. VARIATION IN THE PER CENT OF WEEVIL INFESTATION OF PEAS GROWN ON HILLS AND IN VALLEYS IN THE SAME FIELD

| Location of parallel ridges and valleys | Distance from east end of field | | | | |
|---|---|---|---|---|---|
| | 0 feet | 300 feet | 600 feet | 1400 feet | Averages |
| North side in valley | 74.0% | 81.0% | 77.0% | 69.5% | 75.4% |
| Ridge parallel to north side | 49.5% | 55.2% | 23.5% | 25.0% | 38.3% |
| Valley through center of field | 49.5% | 64.5% | 70.0% | 63.2% | 61.8% |
| Ridge parallel to valley | 49.5% | 12.3% | 15.8% | 34.0% | 27.9% |
| Valley along south side | 90.2% | 42.0% | 53.5% | 61.5% | 61.8% |

Figure 92 shows the infestation found in a 23-acre field with hibernating quarters at both ends of the field. Here the infestation varied from

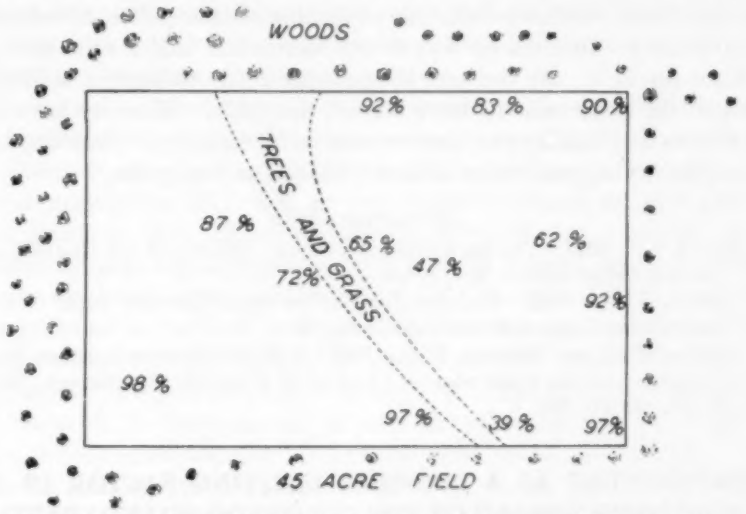


Fig. 93.—Pea weevil infestation in a 45-acre field surrounded by woods.

4 to 26 per cent in different places, being greatest near these hibernating quarters.

Figure 93 shows the infestation in a 45-acre field which was surrounded by woods. Although this was only the second crop of peas, it was heavily infested.

Any section of a field bearing a light stand of peas will usually be found to be heavily infested. This is probably because that section harbors as many weevils as the area about it but not as many peas. Any part of a field left unharvested because the weeds are thick or because the plants are thin will usually furnish a large number of weevils to infest the next year's crop.

The variation in infestation in the different parts of a field depends, to a considerable extent, on the size of the field. The infestation in a large field may be very great in one section and very small in another, while a smaller field would not exhibit this extreme range, and a very small field would contain nearly the same number of weevils throughout its area.

The unequal infestation at harvest time shows that the weevils remain unevenly distributed until after most of their eggs have been deposited. After the blossoms have disappeared and the pods have begun to dry up there is another dispersal of the weevils. They then appear to be more generally distributed over the entire field as well as over weeds in fields and pastures adjoining. This dispersal is caused by a shortage of food. At such times we have found them feeding on the pollen of numerous wild flowers. One weevil was found more than half a mile from the nearest pea field. By the time the peas are ready to harvest in Western Oregon the adult weevils have all left the fields. Here we have been unable to find that any of them return to hibernation. They appear to leave the drying pea plants in search of food and soon die.

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## TEMPERATURE AS A POSSIBLE LIMITING FACTOR IN THE NORTHERN SPREAD OF THE COLORADO POTATO BEETLE

By G. Allen Mail and R. W. Salt[1]

### Abstract

The history of the spread of the Colorado Potato Beetle (*Leptinotarsa decemlineata*) from its native home is briefly reviewed. Data show that the lethal undercooling points of 80 individual beetles ranged from minus 4.3 degrees Centigrade to minus 11.6 degrees Centigrade. The influence of hibernation depth and the probable effect of winter soil temperatures on hibernating beetles is discussed. Data are presented to show the protective influence of a snow covering and some temperature data are tabulated from the Beaverlodge Experimental Station, in the Peace River district of Northern Alberta in an attempt to explain the absence of the beetle in that area, where its native food plants abound.

[1]Contribution from Montana State College, Agricultural Experiment Station. Paper No. 34 Journal Series.

The Colorado Potato Beetle was first found by Thomas Say in Colorado in 1820 on his first Western trip. It was at this time, according to Tower (1906), sparsely distributed over the eastern slope of the Rocky Mountains, then, as now, feeding on the native Solanaceous plants. During the period from 1855 to 1874, due to the western extension of human colonization and the introduction of a new food plant in the cultivated potato, the beetle quickly spread from its relatively restricted habitat, the Rocky Mountain Region, to the Atlantic States.

The two chief barriers to the northward spread of the potato beetle in its wild state were probably food plants and winter temperatures. The northern limit of its original habitat is not clearly known, but was probably in the region of the present international boundary. Two at least of its native food plants, *Solanum triflorum* and *S. rostratum* were indigenous to this district so that insofar as food is concerned its presence in Northern Montana may be assumed.

During its eastward progress it was spreading also north and south, the earliest record of its appearance in Canada being by Bethune (1874) who notes its appearance in Ontario in 1870. It made its appearance in New Brunswick in 1878, was reported from Manitoba in 1879, and in Nova Scotia in 1881. The first definite record of the potato beetle in Western Canada would appear to be in 1899, in Alberta, presumably the extreme southern part of that province, and Gibson et al (1925) mention its appearance in Pincher Creek and Calgary in Alberta, and Moose Jaw, Saskatchewan in 1901. By 1910 it was in the neighborhood of Edmonton, just south of Latitude 54°. In 1927 H. L. Seamans in correspondence stated "The beetle occurs at least 100 miles north of Edmonton" where it does some damage. It has therefore, within the last 50 years, extended its northward range some 400 miles. Less than 100 miles further north of its present range the potato beetle will strike the well settled and fertile plains of the Grande Prairie and Peace River districts. Over this extensive area the beetle will find food in abundance in the cultivated potato, and winter temperatures will probably prove an important limiting factor in its further spread northward.

RESISTANCE OF POTATO BEETLES TO LOW TEMPERATURES.—Considerable experimental work on the effects of low temperatures on the adults of *Leptinotarsa decemlineata* has led to some interesting discoveries. Two of these which concern us here are, first, the wide variability of the undercooling points; and second, the fact that, for this particular insect, freezing is lethal, the undercooling point thus being the minimum vital temperature.

Adults of the potato beetle, upon hibernating in the fall, undergo a

certain amount of hardening. This hardening process is evidenced by a lowering of the freezing and undercooling points, and by a loss in weight. Whether water is bound by the insect is not known. At present we are concerned only with the undercooling points of the insects when in a winter-hardened condition. Artificial hardening of 80 beetles gave a range in undercooling points from —4.3°C. to —11.6°C. with an average of —7.3°C. Salt (1933). These artificial conditions are considered to be fairly representative of natural conditions for two reasons: (1) artificial hardening by exposure to moderately low temperatures has been shown by various workers to duplicate rather well natural winter hardening; (2), it can be shown that the amount of undercooling is not influenced by the rate of cooling within a range of 0.5°C. to 8.5°C. per minute. This range of undercooling temperatures, then, may be considered fairly representative for the species.

With regard to the absolute minimum vital temperature of potato beetle adults, experiments have shown that this temperature is coincidental with the undercooling point of the individual concerned. If the beetle is cooled until ice formation begins, but is warmed again before the freezing process has proceeded much further, it will recover. However, under natural conditions, when the soil reaches such a temperature that ice formation is started, it will in all probability remain at that temperature, or close to it, long enough for the temperature of the insect to come into equilibrium with it. This equilibrium is reached within two to three hours, and proves sufficient to cause the death of the beetle. Therefore if a temperature low enough to start freezing in the insect body is maintained for this short period of time, death results.

The great range of undercooling points found for *Leptinotarsa decemlineata* adults makes it impossible to set a fixed lethal temperature for these insects, but it seems reasonable to conclude that the mortality will vary from 0% at —4° to 100% at —12°C., with a maximum rate of killing at about —7°C.

Depth of Hibernation.—The depth at which the adult beetles hibernate is largely dependent upon the nature of the soil. Observations by various workers show that the beetles cannot penetrate the hardpan and in some districts do not go below the plow line. In loose, sandy soil Gibson (1925) reports them as hibernating at a depth of 14 to 17 inches, and Tower (1906) makes the general statement that the beetle hibernates at a depth of from 18 inches to 2 feet. At this Station we have found beetles in the experimental cages to go down more than four feet in loose sand. For the purpose of discussion one may then conservatively assume a hibernation depth of 12 to 14 inches. The

question then arises as to the chances of survival under winter conditions in the north which hibernating potato beetles will have. The following data on winter soil temperatures throws some light on this question.

AIR AND SOIL TEMPERATURES.—Recent studies at this station have amply demonstrated the protective nature of a snow blanket. Mail (1930) has shown that even as little covering as four inches of snow is an excellent insulation against lethal cold temperatures to soil inhabiting organisms. The soil itself is by no means such a good insulator but with a snow blanket the surface temperature does not usually drop much below freezing even with very severe cold weather. The following figures picked at random from the records demonstrate the point:

| Date | Air temp. | Depth of snow | Soil surface temp. | Temp. at 14" |
|---|---|---|---|---|
| Feb. 15/32.... | —12.3°C. | 8" | —3.8 | —0.2 |
| Mar. 5/32..... | —11.3 | 4 | —1.9 | 0 |
| Mar. 8/32..... | —26.2 | 6 | —1.8 | +0.1 |
| Mar. 10/32.... | —26.1 | 5 | —3.4 | 0 |
| Dec. 7/32..... | —29.8 | 4 | —1.3 | +2.1 |
| Dec. 8/32..... | —30.3 | 4 | —2.8 | +1.2 |
| Dec. 10/32.... | —26.5 | 5 | —3.5 | +0.7 |
| Jan. 16/33.... | —20.3 | 3 | —3.1 | —0.2 |
| Jan. 18/33.... | —14.9 | 4 | —2.9 | —0.1 |
| Feb. 8/33..... | —24.3 | 4 | —6.2 | —2.7 |
| Feb. 9/33..... | —28.5 | 4 | —7.9 | —3.5 |

As stated earlier in this paper, it is highly improbable that there will occur any mortality in normally hardened beetles at —4°C., but —7°C.

| | Feb. 8th °C | Feb. 9th °C |
|---|---|---|
| Air temp. 6 inches | —24.3 | —28.5 |
| 5 " | —21.8 | —26.3 |
| Snow level 4 inches | —18.0 | —22.8 |
| 3 " | —14.9 | —19.3 |
| 2 " | —11.9 | —14.9 |
| 1 " | — 7.2 | — 9.1 |
| Soil surface | — 6.2 | — 7.9 |
| 1 inch | — 5.6 | — 7.2 |
| 2 " | — 5.3 | — 7.0 |
| 3 " | — 5.1 | — 6.8 |
| 4 " | — 4.9 | — 6.5 |
| 5 " | — 4.6 | — 6.2 |
| 6 " | — 4.4 | — 6.0 |
| 8 " | — 3.9 | — 5.2 |
| 10 " | — 3.2 | — 4.6 |
| 12 " | — 3.0 | — 3.8 |
| 14 " | — 2.7 | — 3.5 |
| 16 " | — 2.3 | — 2.9 |
| 18 " | — 1.9 | — 2.5 |
| 20 " | — 1.5 | — 2.2 |
| 22 " | — 1.2 | — 2.0 |
| 24 " | — 0.9 | — 1.6 |
| 3 feet | + 0.9 | + 0.4 |
| 4 " | + 2.2 | + 1.7 |
| 5 " | + 3.2 | + 3.1 |
| 6 " | + 4.4 | + 4.2 |

will probably eliminate large numbers by death. In the preceding table which represents the minimum temperatures observed during two days of unusually severe weather at Bozeman, there might be expected a high mortality in beetles which were trapped in the first 10 inches, but it is unlikely that those at lower depths would suffer.

Furthermore, compacted soil, such as these records were obtained in, is not a particularly good insulator. But ground used for the growing of potatoes is constantly cultivated to depths of from 6 to 9 inches and this loose surface soil may further increase the insulating effect of the winter snows.

The soil temperature picture in the absence of a snow covering is quite different and cold weather with the ground bare may involve great losses in the hibernating beetles. Four days' records of soil temperature during a cold spell from 29th December, 1927 to 4th January, 1928, at Minnesota, with the ground bare, are here given.

| | Dec. 29 | Dec. 31 | Jan. 1 | Jan. 4 |
|---|---|---|---|---|
| Air temp. °C. | —8.5 | —19.5 | —19.8 | —10.0 |
| 2″ | —4.3 | —16.1 | —17.9 | —10.5 |
| 4″ | —3.9 | —15.5 | —17.8 | —10.9 |
| 6″ | —3.1 | —14.0 | —16.3 | —12.3 |
| 8″ | —2.7 | —12.5 | —15.2 | —12.0 |
| 10″ | —2.3 | —10.75 | —13.5 | —11.2 |
| 12″ | —2.1 | — 9.4 | —12.3 | —11.0 |
| 14″ | —1.8 | — 8.2 | —11.1 | —10.6 |
| 16″ | —1.7 | — 6.9 | — 9.7 | — 9.7 |
| 18″ | —1.6 | — 5.7 | — 8.7 | — 9.2 |
| 20″ | —1.5 | — 4.8 | — 7.4 | — 8.4 |
| 22″ | —1.4 | — 4.2 | — 6.6 | — 7.5 |
| 24″ | —1.3 | — 3.6 | — 5.4 | — 6.9 |

Under such conditions it is doubtful whether hibernating beetles within the first two feet would survive, and even the occasional occurrence of conditions similar to that pictured might prove an effective check on the northward movement of the potato beetle. There always remains the question as to the validity of laboratory determinations of winter hardening and just how closely the data arrived at experimentally agree with the normal conditions.

Soil Temperature Data from Beaver Lodge, Alberta.—Thanks to the courtesy of Mr. W. D. Albright, Superintendent of the Dominion Experimental Substation, at Beaverlodge, Alberta, (Fig. 94) some temperature data have been obtained for the winter months during 1928, 1929, and 1930. In 1928 there were 32 days when the minimum air temperature was 15° below zero centigrade, or lower, with a minimum temperature for that year of —40.5°C. In 1929 the days during which the temperature recorded —15 or lower numbered 65 with a minimum of

—42.2°C. In 1930 there were 46 days below —15°C. and a minimum of —36.7°C.

Soil temperatures at Beaverlodge station are taken by means of a soil thermograph, the bulb being placed three inches under the surface of

FIG. 94.—Outline map of Montana, Idaho, Alberta and Saskatchewan.

bare fallow land. Whilst the records give no information on the depth of the snow covering, the annual reports of the station time and again comment on the effect on soil temperatures of the snow present.

From an examination of the temperatures tabulated below and a

comparison of similar temperatures at the Montana and Minnesota Stations, it is possible to interpolate and postulate what temperatures hibernating beetles at Beaverlodge might have to endure.

BEAVER LODGE DATA—Nov.–March, 1928–29–30

Minimum air temperature °C. Minimum soil temperature 3″ °C.

| 1928 | | 1929 Con't. | | 1930 | |
|---|---|---|---|---|---|
| Air | Soil | Air | Soil | Air | Soil |
| —40.5 | — 8.9 | —27.8 | — 8.3 | —22.2 | — 8.3 |
| —33.9 | — 8.9 | —31.11 | — 8.3 | —28.3 | — 8.9 |
| —27.8 | — 8.3 | —36.1 | — 8.3 | —31.1 | — 9.4 |
| —16.7 | — 7.8 | —33.3 | — 7.8 | —36.7 | —10.0 |
| —15.0 | — 3.3 | —42.2 | — 7.2 | —19.4 | — 8.9 |
| —16.11 | — 5.0 | —32.8 | — 7.2 | —21.7 | — 9.4 |
| —17.8 | — 6.1 | —32.8 | — 7.2 | —26.1 | — 9.4 |
| —17.2 | — 6.1 | —33.3 | — 6.7 | —17.2 | — 8.3 |
| —17.8 | — 5.6 | —26.7 | — 7.2 | —21.1 | — 8.3 |
| —16.1 | — 6.1 | —35.0 | — 6.7 | —22.8 | — 8.3 |
| —17.2 | — 7.2 | —32.8 | — 7.2 | —17.8 | — 7.8 |
| —16.1 | — 7.2 | —25.0 | — 7.2 | —28.9 | — 8.3 |
| —17.22 | — 7.2 | —24.4 | — 6.7 | —18.9 | — 7.8 |
| —15.5 | — 7.8 | —23.9 | — 6.7 | —23.9 | — 8.3 |
| —26.1 | — 8.05 | —17.8 | — 6.7 | —32.7 | —10.0 |
| —24.4 | —10.0 | —16.1 | — 6.7 | —38.9 | —11.1 |
| —17.22 | —10.0 | —20.0 | — 4.4 | —20.00 | —10.0 |
| —16.1 | —10.6 | —23.9 | — 5.6 | —22.2 | — 8.9 |
| —23.3 | — 8.9 | —28.3 | — 6.1 | —25.5 | —10.0 |
| —23.3 | — 8.3 | —17.8 | — 6.1 | —22.2 | —10.0 |
| —23.9 | — 8.9 | —18.9 | — 5.0 | —17.2 | —10.0 |
| —17.2 | — 8.3 | —21.1 | — 5.0 | —18.3 | — 8.3 |
| —17.2 | — 7.8 | —21.1 | — 5.0 | —23.3 | — 6.7 |
| —16.11 | — 6.7 | —18.9 | — 5.6 | —30.0 | — 6.9 |
| —26.11 | — 6.7 | —18.9 | — 5.0 | —30.0 | — 7.7 |
| —31.11 | — 6.1 | —16.1 | — 4.4 | —24.4 | — 8.9 |
| —24.4 | — 6.1 | —23.9 | — 5.6 | —16.1 | — 6.1 |
| —17.2 | — 6.8 | —26.11 | — 4.4 | —19.4 | — 6.1 |
| —18.3 | — 6.1 | —17.2 | — 5.0 | —16.6 | — 6.1 |
| —18.3 | — 5.0 | —18.9 | — 3.9 | —16.6 | — 7.2 |
| —20.6 | — | —21.1 | — 4.4 | —15.5 | — 7.2 |
| —15.0 | — 7.2 | —15.5 | — 2.8 | —18.9 | — 7.8 |
| | | —19.4 | — 3.3 | —23.3 | — 8.9 |
| 1929 | | —17.2 | — 5.0 | —18.9 | — 8.3 |
| | | —20.6 | — 5.6 | —16.6 | — 7.2 |
| —20.6 | — 7.8 | —28.3 | — 8.3 | —19.4 | — 8.3 |
| —18.3 | — 8.3 | —28.3 | — 8.9 | —25.0 | — 9.4 |
| —20.0 | —11.1 | —31.7 | — 9.4 | —28.9 | — 7.8 |
| —24.4 | — 8.9 | —32.8 | — 9.4 | —17.2 | — 1.1 |
| —21.7 | — 9.4 | —29.4 | —10.0 | —20.0 | — 1.7 |
| —17.7 | — 7.2 | —28.3 | —10.6 | —15.0 | — 2.2 |
| —23.3 | — 8.3 | —25.0 | — 9.4 | —16.6 | — 1.7 |
| —22.8 | —10.0 | —21.1 | — 6.7 | —16.6 | — 2.2 |
| —22.2 | —10.6 | —26.1 | — 7.8 | —16.1 | — 1.7 |
| —18.3 | —10.0 | —30.0 | — 7.8 | —18.9 | — 1.7 |
| —21.7 | — 8.9 | —27.2 | — 8.3 | —16.6 | — 1.1 |
| —17.2 | —10.0 | —22.2 | — 8.3 | | |
| —27.8 | —10.0 | —21.7 | — 8.3 | | |
| —28.3 | — 8.9 | —22.8 | — 6.1 | | |
| —27.2 | — 8.3 | —15.5 | — 6.1 | | |

It will be observed that the minimum soil temperatures at three inches during each of these three years studied were —10.6, —11.1 and —11.1 respectively. Inasmuch as the spread in soil temperatures in the surface two feet is never large in winter, we may safely assume that with a temperature of minus 10 degrees at three inches, the temperature at two feet would not be much if any higher than minus 7 degrees. As previously stated, laboratory studies have shown that a maximum killing rate might be expected at minus 7°C. Granting that this is correct, during each of the three winters at Beaverlodge for which data are given, there would have been an enormously high percentage of mortality amongst potato beetles hibernating in the first two feet. The fact remains that the potato beetle is not present at Beaverlodge and its food plants are there in abundance, and it would appear reasonable to postulate that these winter soil temperatures are the limiting factor. However, until more definite information is obtained about hibernation depths, one cannot make a positive statement on the matter.

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**The Chinese mantid,** *Paratenodera sinensis* Sauss., has been established in America for a number of years, and in 1930 egg masses were brought to Stamford, Conn., and presumably about that time they were also distributed to certain localities on western Long Island. The year following the insects were found in some numbers. They were somewhat more numerous in the summer of 1932, a number of adults being taken within the City of Stamford, and the past season, 1933, they were decidedly more abundant, and the same appears to be true of localities on western Long Island. The past two or three winters have been somewhat mild, and there is a possibility that the coming, presumably somewhat cold winter, 1933–34, will test the ability of this insect to survive under southern New England and Long Island conditions.

E. P. Felt

# THE IDENTITY OF TWO *LYGUS* PESTS (*HEMIPTERA, MIRIDAE*)[1]

By W. EARL SHULL, *Department of Entomology, University of Idaho, Moscow, Idaho*[2]

ABSTRACT

The scientific and common names of the insects *Lygus elisus* Van Duzee and *Lygus hesperus* Knight have been confused. The insects are now known to be distinct species and are therefore raised from the rank of variety to that of species. Differences between the two insects are given and new common names are proposed.

There appears to be some confusion as to the scientific and common names which should be applied to certain of our western *Lygus*, which in the past few years have become important pests on crops such as beans, alfalfa, apples, pears, bramble fruits, and cotton. The two *Lygus* which have been most commonly misnamed are *Lygus elisus* and *Lugus hesperus*. These insects have been called the "tarnished plant bug," the "tarnished bug," and "cotton daubers," and have been discussed in the literature as *Lygus elisus*, *Lygus pratensis*, *Lygus pratensis oblineatus*, *Lygus elisus* var. *hesperus*, and *Lygus pratensis* var. *hesperus*. *Lygus elisus* was first described by Van Duzee (1914). Dr. Harry H. Knight discussed this insect as *Lygus elisus* Van Duzee (1917). He described *Lygus hesperus* as *Lygus elisus* var. *hesperus* (1917). This worker recently has been determining *Lygus elisus* as *Lygus pratensis elisus* Van Duzee and *Lygus hesperus* as *Lygus pratensis hesperus* Knight.

During recent investigations of the insect pests of beans, the writer has had occasion to study the life history and habits of the two insects, *Lygus elisus* and *Lygus hesperus*. Certain differences have been found which indicate that the two insects are distinct species. Apparently they have the same life history (Shull, 1933), but they have a slight difference in host plants. Both are found breeding in large numbers on legumes, especially clover and alfalfa, as well as many wild host plants. *Lygus elisus* only was observed to feed and breed on the red-rooted pigweed, *Amaranthus retroflexus*. Many nymphs were collected and reared from this plant and in all cases the adults were *Lygus elisus*. A complete survey of the host plants of the two species has not been made, but a study of the data already obtained indicates a possible variation in the host plant range. The two species were found not to interbreed. Attempted matings of males and females of different species failed to produce eggs, while matings of males and females of the same species

[1]Technical Paper No. 93 of the Idaho Agricultural Experiment Station.

[2]The author wishes to express thanks to Dr. H. H. Knight of Iowa State College for his assistance in this study.

produced many fertile eggs, the nymphs from which were reared to adults, and in all instances, they carried the same specific characters as the parent insects. It was observed that the rostra of some of the insects were longer than those of others, which led to a comparative study of rostra of the two insects. A total of 1,789 rostra of males and females was measured (Table 1).

TABLE 1. ROSTRA LENGTHS OF *Lygus hesperus* AND OF *Lygus elisus*

| | *Lygus hesperus* | | | | *Lygus elisus* | | | |
|---|---|---|---|---|---|---|---|---|
| Length of | Male | | Female | | Male | | Female | |
| Rostra mm. | No. | % total | No. | % total | No. | % total | No. | % total |
| 1.9..... | | | | | 13 | 4.15 | | |
| 2.0..... | | | | | 33 | 10.61 | 19 | 5.20 |
| 2.1..... | | | | | 242 | 77.85 | 202 | 56.44 |
| 2.2..... | | | | | 23 | 7.39 | 137 | 38.76 |
| 2.3..... | | | | | | | | |
| 2.4..... | | | | | | | | |
| 2.5..... | 328 | 51.89 | 109 | 22.44 | | | | |
| 2.6..... | 191 | 30.23 | 106 | 21.20 | | | | |
| 2.7..... | 92 | 14.40 | 206 | 42.54 | | | | |
| 2.8..... | 21 | 3.48 | 40 | 8.29 | | | | |
| 2.9..... | | | 27 | 5.53 | | | | |
| Total... | 632 | 100 | 488 | 100 | 311 | 100 | 358 | 100 |

These data show that the length of the rostra of *Lygus elisus* varies between 1.9 mm. and 2.2 mm., and that of *Lygus hesperus* between 2.5 mm. and 2.9 mm., or a difference of 0.3 mm. This difference is small, but constant, and is a very useful character in the identification of the two species. The rostra of *Lygus elisus* never reaches past the hind margin of the metathoracic coxae, while that of *Lygus hesperus* always reaches beyond the hind margin of the metothoracic coxae. The males may further be separated by the color of the venter. The venter of *Lygus elisus* is always green in living specimens. The venter of *Lygus hesperus* is always dark brown to black, or with only yellow bars on each segment. The abdomen of the females is always green in both species (live insects). The green of *Lygus elisus* is a bluish-green, while that of *Lygus hesperus* is yellowish-green both in nymphs and adults. The differences in color pattern of the dorsum also is very valuable in separation of the species. The antennal segments of the males of *Lygus hesperus* are longer than the corresponding antennal segments of *Lygus elisus*, except Segments IV which are equal in length. The over-all length of the antennae of *Lygus hesperus* is therefore greater than that of *Lygus elisus*.

Because of the constant morphological differences in length of the rostra and antennal segments, the slight differences in feeding and

breeding hosts, and because the insects apparently do not interbreed, it is believed by the writer that the two insects, which have recently been considered as varieties of the species *Lygus pratensis*, should be elevated to the rank of species. Such an elevation would give the species described by Van Duzee the name *Lygus elisus*, and that described by Knight the name *Lygus hesperus*.

Many species of the genus *Lygus*, especially of the sub-genus *Lygus*, have been called the "tarnished plant bug." This is not surprising, however, since the species are so closely related and the differences in morphological characters are so small, but the fact that so many of them have been called by the same common name is rather confusing. At the present time, *Lygus pratensis oblineatus* (Say) is recognized as the "tarnished plant bug." *Lygus hesperus* Knight and *Lygus pratensis oblineatus* (Say) have been called by Morrill (1918) the "cotton daubers." *Lygus elisus* Van Duzee was called the "tarnished bug" by McGregor (1927). Each of these species is known to many entomologists and laymen, however, as the "tarnished plant bug;" therefore, because of such confusion and the increasing importance of these pests they should have distinct common names.

Both of the species *Lygus elisus* and *Lygus hesperus* are known to breed throughout their range on alfalfa and clover. This fact was mentioned by Morrill (1918) in Arizona, McGregor (1927) in Arizona and California, and by Webster and Spuler (1931) in Washington. *Lygus elisus* was mentioned by Shull and Wakeland (1931) and by Shull (1933) as the cause of "punctured" beans in Idaho. These papers emphasize the importance of the two species on legumes. Papers discussing their injury to crops other than legumes state that the insects migrate from the legumes to the crop injured. It is quite apparent, therefore, that the two species are closely associated with legumes throughout their range. Because of this association and the apparent confusion as to the common name which should be applied to these two insects, the writer wishes to propose new common names; for *Lygus hesperus* Knight, the "legume bug," and for *Lygus elisus* Van Duzee, the "pale legume bug."

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# INSECTS COLLECTED IN FLIGHT TRAPS IN THE VICINITY OF MOSCOW, IDAHO

By PAUL L. RICE,[1] *Assistant Entomologist, Idaho Agricultural Experiment Station*

ABSTRACT

Flight traps were operated in different types of localities near Moscow, Idaho. The insects caught during two years were determined by specialists. Data on the occurrence and flight habits of approximately 500 species were obtained, of which two-fifths were Coleoptera and one-fifth Hymenoptera.

Insect flight traps were operated near Moscow, Idaho, during the warmer months of 1930 and 1931. The primary purpose of conducting the trap study was to obtain information on the flight habits of the pea weevil, *Bruchus pisorum* (L.), a destructive pest of the region surrounding Moscow. It was soon found, however, that so many insects other than the pea weevil were captured that a valuable contribution to the knowledge of the insect fauna of the vicinity could be made by retaining and studying all of them. This study was undertaken by the writer. It presents in brief form the results obtained.

DESCRIPTION OF THE TRAP.—The trap used in this study was designed by Professor Claude Wakeland and is described in an unpublished paper by him. One of the traps is shown in position in Plate 54. It is sufficient to say here that the trap consisted essentially of a vertical screen panel, at the bottom of which on each side was attached a funnel leading through a small hole into a tin can in such a way that most insects striking the screen and falling through the funnel would be trapped in the can. Some of the insects more active in flight would recover their equilibrium in time to avoid the trap. It was possible to trap insects flying from two sides only. No attractants of any kind were used,

[1]The author wishes to gratefully acknowledge the assistance given him by Professor Claude Wakeland and Dr. W. E. Shull in planning and carrying out the work of this project. He also wishes to acknowledge his deep indebtedness to the 39 specialists who aided him by making determinations.

consequently only those insects that came into contact with the trap during their flights were captured.

LOCATIONS OF TRAPS.—Eight traps were operated during the two years covered in this study. Data on their locations are given in Table 1.

TABLE 1

| Trap No. | Location of trap | Directions faced | Distance above ground of bottom of trap |
|---|---|---|---|
| | **1930 Locations** | | |
| 1 | Within city limits on University water tank | NE and SW | 65 feet |
| 2 | Top of Paradise ridge, 5 miles southeast of Moscow, in woods | N and S | 20 feet |
| 3 | Top of uncultivated knoll 2 miles south of Moscow | E and W | 4 feet |
| 4 | Top of ridge in wheat field 2 miles south of base of Moscow Mt. | NE and SW | 3 feet |
| 5 | Top of high uncultivated knoll next to timber at base of Moscow Mt., 8 miles northeast of Moscow | NE and SW | 4 feet |
| 6 | Top of Moscow Mt. ridge in woods, 10 miles northeast of Moscow | N and S | 15 feet |
| 7 | Low ground in pea field 3 miles west of Moscow | E and W | 6 inches |
| 8 | Side hill in wheat field 3¼ miles west of Moscow | N and S | 6 inches |
| | **1931 Locations** | | |
| 1 | Knoll in wheat field 2½ miles southwest of base of Moscow Mt. | NE and SW | 4 feet |
| 2 | Same as in 1930 | N and S | 20 feet |
| 3 | Same as in 1930 | E and W | 4 feet |
| 4 | Knoll in pea field 3½ miles southwest of base of Moscow Mt. | NE and SW | 4 feet |
| 5 | Same as in 1930 | NE and SW | 4 feet |
| 6 | Same as in 1930 | N and S | 25 feet |
| 7 | Same as in 1930; field planted to wheat | E and W | 4 feet |
| 8 | Same as in 1930; field planted to peas | E and W | 4 feet |

It will be seen that the locations ranged from the top of Moscow Mountain Ridge, 10 miles northeast of Moscow, to a position in cultivated fields three and one-fourth miles west of the city. The traps were suspended from 6 inches to 65 feet above the ground. The approximate elevations of those trap locations that were notably higher than the elevation at Moscow were as follows: Trap No. 2— 3300 feet; Trap No. 3—2950 feet; Trap No. 5—3175 feet; Trap No. 6—4050 feet. The other traps were in locations where the altitude varied from 2650 feet to 2750 feet.

COLLECTIONS FROM TRAPS.—The first collections were made from the traps during the first part of May in both 1930 and 1931. They were discontinued on October 11 in the former year and on November 6 in the latter. Traps Nos. 3, 7 and 8 were not operated after August 1 in 1931. The traps were usually visited at weekly intervals, but sometimes weather conditions or other factors necessitated a deviation from the

Insect flight trap in position in wooden region.

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schedule. All the trapped insects remaining alive when collections were made were killed in cyanide jars. The collections from the different sides of each trap were kept separate, stored, and at a later date all but large series of duplicates and the badly broken specimens were mounted. They were then separated into the larger groups and sent to specialists for determination. All mounted specimens were identified with the exception of about half of the Diptera and the Trichoptera. There appeared to be but one species of the latter order in the collections.

RESULTS.—Nearly 12,000 insect specimens were obtained during the two years. Four hundred ninety-seven species were represented. This number would have been considerably larger had it been possible to identify all specimens obtained. The 497 species were distributed among 12 orders and 108 families, as shown in Table 2. It will be seen here that the orders Coleoptera and Hymenoptera were represented by the largest number of species; over two-fifths of the species captured were Coleoptera and over one-fifth were Hymenoptera.

TABLE 2. NUMBER OF FAMILIES AND SPECIES REPRESENTED UNDER EACH ORDER COLLECTED

| Name of order | Number of families | Number of species | Name of order | Number of families | Number of species |
|---|---|---|---|---|---|
| Orthoptera | 3 | 8 | Hemiptera | 14 | 56 |
| Isoptera | 1 | 1 | Coleoptera | 39 | 211 |
| Neuroptera | 3 | 4 | Trichoptera | 1 | 1 |
| Ephemerida | 1 | 5 | Lepidoptera | 7 | 32 |
| Corrodentia | 1 | 1 | Diptera | 11 | 30 |
| Homoptera | 6 | 33 | Hymenoptera | 21 | 115 |
| Total | | | | 108 | 497 |

A comparatively small number of the species appeared in both 1930 and 1931, for only 134 species, 27 per cent of the total, were collected both years. The total number of species collected in 1930 was 372, while in 1931 it was but 259. Two hundred thirty-eight species which did not appear at all in 1931 were collected in 1930, while 125 species were collected only in 1931. Although a large majority of those species which appeared one year only were represented by but one specimen, as high as 55 specimens of a species were collected one year, while not a single representative of that species was obtained the other year. Even when a species appeared both years, there was often a large variation in the number of specimens captured each year. For example, 189 specimens of a leafhopper, *Euscelis* sp., were collected in 1930, while in 1931 the number had increased to 1207, an increase of nearly 700 per cent.

The specimens collected of an individual species ranged in number from one to 3,387. Only one specimen each of 261 species was collected.

Those species having more than 100 representatives in the collections were as follows: *Bruchus pisorum* (L.), the pea weevil, 3,387 specimens; *Aphodius distinctus* (Mull.), a small dung beetle, 2,653 specimens; *Euscelis* sp., a leafhopper, 1,396 specimens; *Mycterus concolor* Lec., a melandryid beetle, 226 specimens; and *Bibio xanthopus* var. *palliatus* McAtee, a marchfly, 117 specimens.

Some species of insects showed a very limited distribution over the area covered by the traps while others were widely distributed. Many species were found only in traps in wooded regions, while others were found only in the cultivated areas. The outstanding example of an insect distributed widely over the area was the dung beetle, *Aphodius distinctus* (Mull.), which was collected both years in all eight traps. The finding of some insects in traps remote from their normal breeding areas gives evidence of flights of considerable distances. The bark beetle, *Scolytus ventralis* Lec., the host of which is the lowland white fir, was collected in greater abundance in traps remote from wooded districts than in the traps situated in or near these areas. One such specimen was collected in a trap at a distance of six miles from a white fir stand, showing that the species must travel long distances in search of suitable host trees.

The number of species collected each week was greatest in the spring. The maximum number of species was obtained the week ending May 17 in 1930, while in 1931 the year's maximum was reached the week ending May 30. There was a decrease in the number of species obtained per week until the low point of the year was reached the latter part of August and the first part of September. Then there was an increase in numbers until the cold weather set in.

The collection of *Mysia randalli* Csy., a coccinellid beetle, in the traps at Moscow, contributed to the knowledge of its range. Dr. Th. Dobzhansky, who identified the Coccinellidae, in commenting on the occurrence of this insect in Idaho, says: ". . . This is a species known so far only from the region between Lake Superior and Labrador. Its occurrence in Idaho is rather unexpected . . . "

The locations of the traps had no consistent effect on the number of species captured; neither did the direction faced by the traps consistently influence the number of specimens collected. As a rule, more species were captured in traps on high ground than in those on low ground. The number of species captured in the trap suspended 65 feet above the ground was greater than in some traps placed near the ground, but less than in other lowly suspended traps. There was no consistent difference in the number of species caught in cultivated and wooded

areas. Since the prevailing wind in the Moscow vicinity is from the southwest it would seem logical to suppose that more insects would be collected on the south, southwest and west sides of the traps than on the opposing sides. This proved to be true in 1930. However, the reverse proved to be the case in 1931, because in every trap a larger number of insects was captured in the side facing away from the source of the prevailing wind. Since southwest winds seemed to be more prevalent in 1931 than in 1930, the prevailing wind did not seem to influence the catch on the different sides of the traps.

## A METHOD FOR TEMPORARY INHIBITION OF COAGULATION IN THE BLOOD OF INSECTS[1]

By W. EARL SHULL and PAUL L. RICE, *Department of Entomology, University of Idaho, Moscow, Idaho*

ABSTRACT

Any desired degree of inhibition of coagulation in the blood of the cockroach may be obtained by treating the roaches (*Blatella germanica* and *Periplaneta orientalis*) with acetic acid vapors when the time of exposure and temperature are controlled. The apparatus and technique employed in subjecting the cockroaches to acetic acid vapor together with some data obtained by the use of this method are presented.

In a study of the effect of certain toxic gases upon the coagulation of the blood of the cockroach Shull, Riley and Richardson (1932), observed that, in those insects which were exposed to the vapors of glacial acetic acid, coagulation of the blood was temporarily inhibited and that the blood cells appeared normal as in uncoagulated blood. Normal coagulation of the blood of the cockroach was described by Yeager, Shull and Farrar (1932). This paper is a report of further work with acetic acid vapor in its effect on coagulation of insect blood. The laboratory animals used in this study were the German cockroach, *Blatella germanica*, and the oriental cockroach, *Periplaneta orientalis*.

An insect to be treated was placed in the bottom of a glass tube which was one inch in diameter and eight inches long. The bottom of the tube was perforated by numerous holes. Two corks were attached to a thermometer which was suspended in the tube. The lower cork, which was of the proper size to slip easily within the tube, was attached in an inverted position just above the bulb of the thermometer. The upper cork, which closed the top of the tube, was attached so that when it was in position the lower cork would be one and one-half inches from the

[1]Technical paper No. 99, Idaho Agricultural Experiment Station.

bottom of the tube. Both corks were dipped in paraffin to prevent the absorption of acetic acid vapor. When the corks and thermometer were in place, the insect was confined to the lower one and one-half inches of the tube, and the temperature of that area could be read at all times. This tube and its contents was placed inside another tube which was slightly larger in diameter and one-half inch longer. The larger tube was suspended from a clamp into a constant temperature bath so that the lower six inches of the tube was immersed in the water. The opening between the two tubes was loosely sealed at the top by means of rubber bands wound around the inner tube. The insect was subjected to bath temperatures in this manner for ten minutes or more in most cases. This was thought to be sufficient time for the temperature of the insect's body to reach that of the bath. At the end of this period, the inner tube containing the insect was rapidly transferred to another large tube immersed in the bath. This tube was of the same size and shape as the first outer tube but contained in the bottom 2 cc. of acetic acid. After exposure to acetic acid vapor for the desired length of time, the insect was taken out and a drop of blood was immediately removed by severing an antenna, and dipping the severed end into a drop of nujol oil on a slide glass. The blood was then examined under a compound microscope. Treated insects were retained for observation in glass-tube or pill-box cages.

Four pairs of the treating tubes described above were used in the study. Consequently two or three insects could be warmed in the bath while the fourth was being treated. It was found that only slight change in temperature was produced when the tube containing an insect was transferred from the tube in which it had been warming to one containing the acetic acid. The perforated tubes were wiped out after each treatment in order to remove any moisture that had accumulated. New glacial acetic acid was used for each day's treatments.

The procedure and apparatus described in the foregoing paragraphs were those that were finally used. All specimens of *P. orientalis* were treated as described above, however the treatment of specimens of *B. germanica* varied somewhat. The corks used while working with this species were not dipped in paraffin to prevent absorption of acetic acid vapor. As a consequence the odor of acetic acid could easily be detected on these corks. The small amount of vapor released from them possibly affected the insects to a slight degree while being warmed and before they were suspended in the tube containing the acid.

A small number of specimens of two Coleopterous species were subjected to the acid treatment. A few cockroach specimens were sub-

jected to the higher temperatures in the range investigated without treating with acid.

The sex of the insect, the length of time the insect was in the bath before treatment, the length of the period of treatment, and the vapor temperature at the time of treatment were recorded. Note was made as to whether or not coagulation of the blood had occurred within one or two minutes after removal from the insect and whether or not it had occurred 24 hours or more later. Whether the insect was living or dead at these two periods was also recorded. The results obtained from treatment of 71 specimens of *Blatella germanica* are given in Table 1, and results obtained from treatment of 104 specimens of *Periplaneta orientalis* in Table 2. The entire series of *P. orientalis* treated were males. The notation "x" in the "Coagulation of blood" column signifies that coagulation had occurred. The notation "–" in this column indicates that coagulation had not occurred. In the "Insects alive" column an "x" means that the insect was living at the time of observation and a "–" means that it was dead. If any movement was exhibited by the insect, it was recorded as living. Consequently, when an insect was recorded as living it should not be inferred that it was normal. Where a question mark occurs, the droplet of blood had either dried or some other factor had made it impossible to determine the state of coagulation.

TABLE 1. THE EFFECT OF ACETIC ACID VAPOR ON THE GERMAN COCKROACH, *Blatella germanica*

| Insect No. | Treatment in minutes warming | acid | Temp. at time of acid treatment | Coagulation of blood At removal | 24 hrs. after removal | Insect alive At removal | 24 hrs. after removal | Sex |
|---|---|---|---|---|---|---|---|---|
| 1 | 10 | 3.6 | 20.0°C | x | x | x | x | female |
| 2 | 10 | 3.5 | 21.0 | x | x | x | x | female |
| 3 | 10 | 3.4 | 22.0 | x | x | x | x | female |
| 4 | 10 | 3.3 | 23.0 | x | x | x | x | female |
| 5 | 10 | 3.5 | 23.0 | x | x | x | x | female |
| 6 | 10 | 3.5 | 23.0 | – | ? | x | x | male |
| 7 | 10 | 3.7 | 23.0 | – | – | x | x | female |
| 8 | 10 | 3.6 | 24.0 | x | x | x | x | male |
| 9 | 10 | 3.5 | 25.0 | x | x | x | x | female |
| 10 | 10 | 1.0 | 25.5 | x | x | x | x | male |
| 11 | 10 | 4.0 | 25.5 | – | – | x | x | male |
| 12 | 10 | 2.0 | 26.0 | x | x | x | x | male |
| 13 | 10 | 2.5 | 26.0 | x | x | x | x | male |
| 14 | 10 | 3.0 | 26.0 | – | – | x | x | male |
| 15 | 10 | 3.0 | 26.0 | – | – | x | x | male |
| 16 | 10 | 3.4 | 26.0 | – | – | x | x | male |
| 17 | 10 | 3.5 | 26.0 | – | – | x | x | male |
| 18 | 10 | 3.6 | 26.0 | – | – | x | x | female |
| 19 | 10 | 5.0 | 26.0 | – | ? | x | x | female |
| 20 | 10 | 3.3 | 27.0 | x | x | x | x | female |
| 21 | 10 | 3.2 | 28.0 | – | x | x | x | male |
| 22 | 10 | 2.7 | 29.0 | – | x | x | x | male |
| 23 | 10 | 2.0 | 30.0 | x | x | x | – | male |

TABLE 1 *Concluded*

| Insect No. | Treatment in minutes warming | acid | Temp. at time of acid treatment | Coagulation of blood At removal | 24 hrs. after removal | Insect alive At removal | 24 hrs. after removal | Sex |
|---|---|---|---|---|---|---|---|---|
| 24 | 10 | 2.6 | 30.0 | x | x | x | x | female |
| 25 | 10 | 2.6 | 30.0 | – | – | x | x | male |
| 26 | 10 | 2.6 | 30.0 | – | – | x | x | male |
| 27 | 10 | 2.6 | 30.0 | x | x | x | x | female |
| 28 | 10 | 3.5 | 30.0 | – | – | x | – | male |
| 29 | 20 | 1.0 | 31.0 | x | x | x | x | male |
| 30 | 5 | 2.0 | 31.0 | – | x | x | x | female |
| 31 | 13 | 2.0 | 31.0 | No blood | | x | x | male |
| 32 | 10 | 2.25 | 31.0 | x | x | x | x | male |
| 33 | 10 | 2.5 | 31.0 | – | – | x | – | male |
| 34 | 10 | 2.5 | 31.0 | – | x | x | – | male |
| 35 | 10 | 2.9 | 31.0 | x | x | x | x | female |
| 36 | 5 | 3.0 | 31.0 | – | – | x | x | male |
| 37 | 10 | 3.0 | 31.0 | – | ? | x | – | male |
| 38 | 5 | 3.5 | 31.0 | – | – | x | x | male |
| 39 | 5 | 3.5 | 31.0 | – | x | x | x | female |
| 40 | 10 | 2.4 | 32.0 | x | x | x | – | male |
| 41 | 10 | 3.0 | 32.0 | – | – | x | x | female |
| 42 | 10 | 2.3 | 33.0 | – | – | x | x | male |
| 43 | 10 | 2.95 | 33.0 | – | – | x | x | female |
| 44 | 10 | 2.2 | 34.0 | x | x | x | x | male |
| 45 | 10 | 2.8 | 34.0 | – | – | x | x | female |
| 46 | 10 | 2.1 | 35.0 | – | – | x | x | male |
| 47 | 10 | 2.7 | 35.0 | – | – | x | – | female |
| 48 | 10 | 1.0 | 35.5 | x | ? | x | x* | female |
| 49 | 14 | 1.0 | 36.0 | x | x | x | x | male |
| 50 | 10 | 1.5 | 36.0 | – | ? | x | –* | male |
| 51 | 14 | 1.5 | 36.0 | x | x | x | x | male |
| 52 | 15 | 1.75 | 36.0 | – | x | x | x | male |
| 53 | 10 | 2.0 | 36.0 | – | – | x | x | male |
| 54 | 10 | 2.0 | 36.0 | – | – | x | – | male |
| 55 | 10 | 2.5 | 36.0 | – | ? | x | –* | female |
| 56 | 10 | 2.6 | 36.0 | – | – | x | x | female |
| 57 | 10 | 2.0 | 36.5 | – | ? | x | –* | male |
| 58 | 10 | 2.1 | 37.0 | – | – | x | x | male |
| 59 | 10 | 2.5 | 37.0 | – | – | x | x | female |
| 60 | 10 | 2.0 | 38.0 | – | – | x | – | male |
| 61 | 10 | 2.4 | 38.0 | – | – | x | x | female |
| 62 | 10 | 1.9 | 39.0 | – | – | x | – | male |
| 63 | 10 | 2.3 | 39.0 | – | x | x | x | female |
| 64 | 10 | 1.8 | 40.0 | – | – | – | – | male |
| 65 | 10 | 2.2 | 40.0 | – | – | x | x | female |
| 66 | 10 | 0.5 | 40.5 | x | x | x | x* | female |
| 67 | 11 | 1.0 | 41.0 | – | ? | x | x* | female |
| 68 | 10 | 1.5 | 41.0 | – | – | x | – | male |
| 69 | 10 | 1.9 | 41.0 | – | – | x | x | female |
| 70 | 10 | 1.5 | 41.5 | No blood | | x | –* | female |
| 71 | 10 | 1.5 | 41.5 | – | ? | x | –* | male |

*Observation was made six days after treatment.

DISCUSSION.—These data show that coagulation of the blood of the German and the oriental cockroaches may be influenced by subjecting the insects to a treatment of acetic acid vapor. Different degrees of inhibition may be produced which vary from a slight slowing up of the

TABLE 2. THE EFFECT OF ACETIC ACID VAPOR ON THE ORIENTAL COCKROACH, *Periplaneta orientalis*

| Insect No. | Treatment in minutes warming | acid | Temp. at time of acid treatment | Coagulation of blood At removal | 24 hrs. after removal | Insect alive At removal | 24 hrs. after removal |
|---|---|---|---|---|---|---|---|
| 1 | 15 | 4.5 | 24.8°C. | x | x | x | x |
| 2 | 15 | 6.0 | 25.0 | x | x | x | x |
| 3 | 15 | 6.5 | 25.0 | x | x | x | x |
| 4 | 15 | 7.0 | 25.0 | – | – | x | x |
| 5 | 15 | 7.5 | 25.0 | x | x | x | x |
| 6 | 15 | 8.0 | 25.0 | – | – | x | x |
| 7 | 15 | 8.5 | 25.0 | – | – | x | x |
| 8 | 15 | 9.0 | 25.0 | – | – | x | x |
| 9 | 15 | 9.0 | 25.0 | x | x | x | x |
| 10 | 15 | 9.5 | 25.0 | – | – | x | x |
| 11 | 15 | 10.0 | 25.0 | – | – | x | x |
| 12 | 15 | 10.5 | 25.0 | – | – | x | x |
| 13 | 15 | 11.0 | 25.0 | – | – | x | x |
| 14 | 15 | 11.5 | 25.0 | – | – | x | x |
| 15 | 15 | 12.0 | 25.0 | – | – | x | – |
| 16 | 15 | 12.0 | 25.0 | x | x | x | x |
| 17 | 15 | 12.5 | 25.0 | – | – | x | x |
| 18 | 15 | 12.5 | 25.0 | – | ? | x | x |
| 19 | 15 | 13.0 | 25.0 | – | – | x | x |
| 20 | 15 | 13.0 | 25.0 | – | – | x | x |
| 21 | 15 | 13.6 | 25.0 | – | – | x | – |
| 22 | 15 | 14.0 | 25.0 | – | – | x | x |
| 23 | 15 | 15.0 | 25.0 | – | – | x | x |
| 24 | 15 | 15.0 | 25.0 | – | – | x | x |
| 25 | 15 | 17.5 | 25.0 | – | – | x | – |
| 26 | 15 | 19.2 | 25.0 | – | ? | x | – |
| 27 | 15 | 20.0 | 25.0 | – | – | x | – |
| 28 | 15 | 12.5 | 26.0 | x | x | x | x |
| 29 | 15 | 14.5 | 26.0 | – | – | x | x |
| 30 | 15 | 14.0 | 27.0 | – | – | x | – |
| 31 | 15 | 13.5 | 28.0 | – | – | x | – |
| 32 | 15 | 13.2 | 29.0 | – | – | x | x |
| 33 | 10 | 2.5 | 30.0 | x | x* | x | x* |
| 34 | 10 | 3.0 | 30.0 | x | x* | x | x* |
| 35 | 10 | 3.5 | 30.0 | – | x* | x | x* |
| 36 | 10 | 4.0 | 30.0 | – | –* | x | –* |
| 37 | 10 | 4.5 | 30.0 | x | x* | x | x* |
| 38 | 10 | 5.0 | 30.0 | x | x* | x | –* |
| 39 | 10 | 5.5 | 30.0 | – | –* | x | x* |
| 40 | 10 | 6.0 | 30.0 | – | –* | x | x* |
| 41 | 10 | 6.5 | 30.0 | – | ?* | x | –* |
| 42 | 10 | 6.5 | 30.0 | – | –* | x | x* |
| 43 | 10 | 7.0 | 30.0 | – | –* | x | –* |
| 44 | 10 | 7.5 | 30.0 | – | –* | x | x* |
| 45 | 10 | 8.0 | 30.0 | x | x* | x | x* |
| 46 | 15 | 9.0 | 30.0 | – | –* | x | x* |
| 47 | 15 | 10.0 | 30.0 | – | –* | x | x* |
| 48 | 15 | 11.0 | 30.0 | – | –* | x | –* |
| 49 | 15 | 12.5 | 30.0 | – | – | x | x |
| 50 | 15 | 12.0 | 31.0 | – | –** | x | – |
| 51 | 15 | 11.5 | 32.0 | – | –** | x | –** |
| 52 | 15 | 11.0 | 33.0 | – | –** | x | –** |

*Observation made 48 hours after treatment.
**Observation made 66 hours after treatment.

TABLE 2. *Concluded*

| Insect No. | Treatment in minutes warming | acid | Temp. at time of acid treatment | Coagulation of blood At removal | 24 hrs. after removal | Insect alive At removal | 24 hrs. after removal |
|---|---|---|---|---|---|---|---|
| 53 | 15 | 10.5 | 34.0 | – | –** | x | –** |
| 54 | 15 | 1.5 | 35.0 | x | x | x | x |
| 55 | 15 | 2.0 | 35.0 | x | x | x | x |
| 56 | 15 | 2.5 | 35.0 | – | – | x | x |
| 57 | 15 | 3.0 | 35.0 | – | – | x | x |
| 58 | 15 | 3.5 | 35.0 | – | – | x | x |
| 59 | 15 | 4.5 | 35.0 | – | – | x | x |
| 60 | 15 | 5.5 | 35.0 | – | – | x | x |
| 61 | 15 | 6.5 | 35.0 | – | – | x | x |
| 62 | 15 | 7.5 | 35.0 | – | – | x | x |
| 63 | 15 | 8.5 | 35.0 | – | – | x | x |
| 64 | 15 | 9.0 | 35.0 | – | – | x | x |
| 65 | 15 | 10.0 | 35.0 | – | –** | x | –** |
| 66 | 15 | 9.5 | 36.0 | – | –** | x | –** |
| 67 | 15 | 9.0 | 37.0 | – | –** | x | –** |
| 68 | 15 | 8.5 | 38.0 | – | –** | x | –** |
| 69 | 15 | 8.0 | 39.0 | – | –** | x | –** |
| 70 | 15 | 1.0 | 40.0 | x | x | x | x |
| 71 | 15 | 1.5 | 40.0 | x | x | x | x |
| 72 | 15 | 2.0 | 40.0 | – | – | x | x |
| 73 | 15 | 2.0 | 40.0 | – | x | x | x |
| 74 | 15 | 2.0 | 40.0 | – | x | x | x |
| 75 | 15 | 2.0 | 40.0 | – | x | x | x |
| 76 | 15 | 2.0 | 40.0 | x | x | x | x |
| 77 | 15 | 2.25 | 40.0 | x | x | x | x |
| 78 | 15 | 2.5 | 40.0 | – | – | x | x |
| 79 | 15 | 2.5 | 40.0 | – | x | x | x |
| 80 | 15 | 2.5 | 40.0 | – | x | x | x |
| 81 | 15 | 2.75 | 40.0 | – | x | x | x |
| 82 | 15 | 3.0 | 40.0 | – | x | x | x |
| 83 | 15 | 3.25 | 40.0 | – | – | x | x |
| 84 | 15 | 3.25 | 40.0 | – | x | x | x |
| 85 | 15 | 3.5 | 40.0 | x | x | x | x |
| 86 | 15 | 3.5 | 40.0 | x | x | x | x |
| 87 | 15 | 4.0 | 40.0 | – | – | x | – |
| 88 | 15 | 4.0 | 40.0 | – | – | x | x |
| 89 | 15 | 4.0 | 40.0 | – | – | x | – |
| 90 | 15 | 4.5 | 40.0 | – | – | x | x |
| 91 | 15 | 7.5 | 40.0 | – | – | x | – |
| 92 | 15 | 7.0 | 41.0 | – | – | x | – |
| 93 | 15 | 6.5 | 42.0 | – | – | x | – |
| 94 | 15 | 6.0 | 43.0 | – | – | x | – |
| 95 | none | 1.0 | 44.0 | x | x | x | x |
| 96 | none | 1.5 | 44.0 | x | x | x | x |
| 97 | none | 2.0 | 44.0 | – | – | x | x |
| 98 | 15 | 5.5 | 44.0 | – | – | x | – |
| 99 | none | 5.5 | 44.5 | – | – | x | – |
| 100 | 12 | 1.5 | 45.0 | – | – | – | – |
| 101 | 15 | 2.0 | 45.0 | – | – | – | – |
| 102 | none | 3.0 | 45.0 | – | – | x | x |
| 103 | none | 4.0 | 45.0 | – | – | x | – |
| 104 | 15 | 5.6 | 45.0 | – | – | x | – |

*Observation made 48 hours after treatment.
**Observation made 66 hours after treatment.

normal coagulation processes to inhibition which extends over two days or more. It is obvious that the length of exposure and temperature of exposure are factors which influence the degree of inhibition secured. If the tables be analysed, it will be seen that, in general, the time of exposure required to stop coagulation varied inversely as the temperature. There was some individual variation in the time required to inhibit coagulation at any one temperature. This was probably due to differences in physiological conditions of the insects treated. It is quite probable that age variation may have a considerable influence upon the ability of the insect to survive treatment with acetic acid vapor.

It was found that coagulation could be inhibited in the two species of Coleoptera which were treated with acetic acid.

Subjection of insects to temperatures of 40° C. or above has a very marked effect on the coagulation processes. The coagulation of the blood was inhibited for varying lengths of time when roaches were subjected to temperatures of 40° and 45° for fifteen minutes, without acid treatment. However, many of the cells in blood taken from *P. orientalis* specimens subjected to temperatures of 45° were very irregular in shape.

A small number of the insects treated appeared to regain normality after treatment, but a large majority of them, although alive at the end of the treatment and usually alive 24 hours later, were abnormal in appearance, and most of them died within a few days. Some of the specimens treated at the higher temperatures were dead at the end of the treatment and a few were lifeless at the end of the warming period, before treatment with acid. However, many of the roaches which had been treated until coagulation was inhibited for a very short time, and a few in which coagulation was stopped for 24 hours, were apparently normal soon after removal, and seemed to be normal up to several days thereafter. This seems to indicate that when an insect is subjected to the right length of exposure to acetic acid vapor, coagulation may be inhibited and yet the insect will return to apparent normality. This method of treatment should prove very useful in the study of many phases of insect physiology and toxicology where it is necessary to study the blood in its normal morphological form.

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# WESTERN WILLOW TINGID, *CORYTHUCHA SALICATA* GIBSON, IN OREGON[1]

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and KWAN LUN WONG

ABSTRACT

Notes on life history, distribution on apples in Oregon and control measures are discussed. The overwintering adults were found quite difficult to kill with the sprays tried. The nymphs were killed readily by most of the insecticides used. Pyrethrum extracts, nicotine sulfate 40%, oil emulsions and whale oil soaps were tried alone and in combination.

Tingids, commonly known as lace bugs, are small, flat, oval or oblong insects with reticulated upper surfaces often lace-like in appearance, hence the common name. They are often regarded as an unimportant pest on account of their infestation being mostly on the uncultivated plants and their occurrence in small numbers.

In several Oregon orchards during the last few years, the western willow tingid, *Corythucha salicata* Gib., occurred abundantly on apple and sparingly on willow, which is supposed to be its chief host, even though the latter plant is found in the same orchard. Infestation has increased each year. The following study of a year's work merely serves as a preliminary report and awaits further research on the different phases of the problem.

DISTRIBUTION.—The western willow tingid, *Corythucha salicata* Gib., has been reported from Oregon, Washington, Manitoba and British Columbia. In Oregon it has been found doing damage on apple in Lebanon, Salem and Dallas, and has been recorded from Monroe, Portland, Hood River and Corvallis.

ECONOMIC IMPORTANCE.—Adults, as well as nymphs, procure their food by sucking the juice in the leaf tissue. The injury resulting to the plant is indicated by the brown and sunburnt appearance of the leaves. The black excrement and moulted skins of the nymphs on the undersurfaces of the leaves give a good identifiction of the presence of the pest. The tissue surrounding the eggs is somewhat hard and corky, and distortion of the ribs may happen where many eggs are deposited on a leaf. An infested orchard can be recognized by a brown unhealthy color instead of a rich green appearance. By the middle of July most of the injured leaves turn brown, dry up and fall, and the orchard resembles

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the winter condition. A heavily infested orchard was so damaged by the tingid that practically 100 per cent of the crop was lost.

## Description of Stages

*Adults.* Size of female is 3.55 by 2 mm. Male is a little smaller, being 3.45 by 1.9 mm. Color in general is above white or creamy with a brown band near the apex and a faint brown band across the base of the elytra. A brown spot at the center of the costal margin and the brown tumid elevation of the elytra are usually very prominent. There are comparatively few spines on the membranous margins and nervures. Pronotal hood is slightly higher than median carina and height of hood is about one-half its own length (Fig. 95, 1). Median carina is of normal height. Lateral carinae are long and terminate a short distance from base of hood. Reticulations of globose portion of hood are about the same size as those of paranota. The western willow tingid was first described by Gibson and named *Corythucha salicata* (1*). The type is taken from Hood River, Oregon.

In the same paper Gibson described another tingid as a new species, called *Corythucha drakei*, which is taken from apple tree in Portland, Oregon. He distinguished *salicata* from *drakei* by the less arched median carina, which is slightly shorter, and by the angulate tumid elevations of the elytra. Drake, 1921 (2) reports that it is impossible to separate *C. drakei* from *C. salicata*, and considers *drakei* as a synonym of *salicata*, according to the law of priority.

*Egg* (Fig. 95, 3). The eggis small, light brown and semitransparent in basal half; subelliptical in outline and slightly curved. The basal end is rather bluntly pointed and the apical end capped with a narrow cylindrical collar surmounted by a low pyramid with ridges extending from the base to the apex. The pyramidal portion of the apical end is greyish in color. Below the collar the exposed portion of the egg is covered with a black, sticky substance which hardens soon after oviposition. The length of the egg averages .47 mm. with its width .19 mm.

*Nymphs* (Fig. 95, 4, 5, 6). *First nymphal stage.* General form more cylindrical, elongated and thicker than the other instars. Length varying from .52 to .68 mm.; the greatest width from .23 to .28 mm. At the time of hatching the nymph is pale in color. Fully matured specimens are dirty yellow. Antennae three-segmented; rostrum four-segmented and about three-fifths as long as the entire body; legs long and stout. Head bears five tubercles with spines on them. Both prò- and meso-thorax are armed with a spine on each. Meso-thorax also with a dorsal pair of tubercles. Abdomen consists of ten segments; segments two to nine each with a small tubercle bearing a slender spine on each side.

*Second nymphal stage.* The change which occurs in the first moult is not great. Body is broader. Length varies from .85 to .95 mm.; the greatest width from .41 to .45 mm. Color is darker yellow. Spines are stronger and longer with additional ones on various regions.

*Third nymphal stage.* Length varies from 1.07 to 1.12 mm.; the greatest width from .50 mm. to .58 mm. Antennae become four-segmented. The legs are slender and shorter in proportion to the length of the body than before.

*Fourth nymphal stage.* The most noticeable change which takes place in the fourth stage is the first appearance of the wing pads, which arise as curved, backward growths of the sides of the meso-thorax. The wing pads extend back on each

*Literature cited.

side to the middle of the second abdominal segment. The pro-thorax is proportionately longer than before and bears two pairs of dorsal tubercles. The general color is

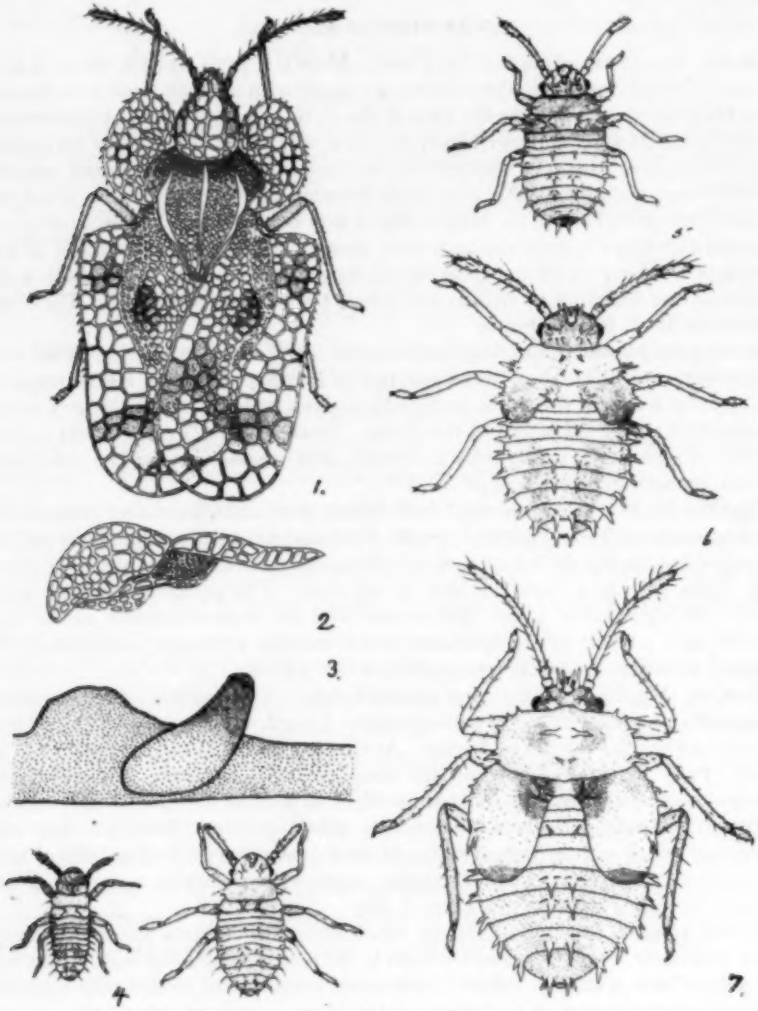


FIG. 95.—Western willow tingid and its various stages

yellow with wing pads embrowned. Length varies from 1.35 to 1.50 mm.; the greatest width from .81 to .87 mm.

*Fifth nymphal stage.* The most noticeable changes which occur in the fifth stage are the increased length of the prothorax in proportion to the length of the body, and the increase in length of the wing pads. The wing pads now extend back on each side to the middle of the fifth abdominal segment. The pro-thorax is very promi-

nent, the median anterior portion being considerably raised and inflated. The general color is yellow with tips of the wing pads embrowned and with 2 prominent brown spots near the base of the dorsal tubercles on the wing pads. Length varies from 2 to 2.25 mm.; the greatest width from 1.12 to 1.25 mm.

## Life History and Habits

*Eggs.* The eggs are deposited on the under surface of the leaf, usually along both sides of the ribs, especially the midrib. About three-fifths of the egg is inserted into the tissue, leaving the two-fifths protruding from the leaf (Fig. 95, 3). The exposed portion of the egg is covered with a black sticky substance. The eggs are generally placed singly and in no definite order.

The eggs are deposited during the latter part of April until beginning of July. They are quite large in proportion to the size of the abdomen. The ovary can contain only a few fully formed ova at one time. This probably accounts for the long period of egg deposition. The number of eggs found in a single leaf varies from 50 to 528 in a leaf 6 cm. long and 3.5 cm. in diameter. Judging by the first field observation of eggs and the first field observation of newly hatched nymphs, it takes about three weeks for the incubation period.

*Nymphs.* The gregarious habit of the nymphs is more pronounced in the first two instars. They gradually scatter during the older stages. Newly hatched nymphs are not so active and are found moving not far away from the empty egg cases. Moulting skins of the first instar nymphs are found on the leaves where eggs are laid. Nymphs of all instars feed on the underside of the leaves where they suck the sap of the tissue and cause the leaves to dry. Discoloration caused by their feeding is very conspicuous on both sides of the leaves. In addition to this discolored area, there are small black spots on the underside of the leaves where the excrement has been deposited.

The nymphal stages are represented by five instars. All stages are found in the field from middle of June to the end of July. The length of the different instars is as follows:

| | |
|---|---|
| 1st instar | 3 to 6 days |
| 2nd instar | 3 to 5 days |
| 3rd instar | 3 to 5 days |
| 4th instar | 5 to 9 days |
| 5th instar | 4 to 8 days |

*Adults.* Adults, like the nymphs, feed on the underside of the leaves and injure them in the same manner. They are also gregarious in habit. Hundreds of them may be found clustering in a single leaf. They are not actively flying insects, being spread gradually in the orchard.

The winter is passed in the adult stage and hibernation begins early in September. Wilson and Lovett (3) report that hibernation takes place in the rubbish on the ground. Under field observation it is found that most adults hibernated among the moss on standing trees in or near the orchard, and sparingly in rubbish on the ground or under bark of trees. There were 711 hibernating adults found in one liter of moss from standing trees near the orchards. In all cases where tingids have done damage to apples in the Willamette Valley, there were adjacent to the orchards, woods, usually of oak, heavily covered with moss and invariably infestation started on the trees next to the woods.

The overwintering adults come out on warm days in the spring. In Lebanon, where the most serious infestation has occurred, it was found averaging 10 insects per bud after they left their hibernating quarters. In one severe case 112 tingids were found in a single bud. The adults first appear on the trees near the hibernation quarters and keep on spreading in the orchard. Feeding and mating were observed soon after emergence. Eggs were laid about three weeks later and brood rearing of the season started.

SEASONAL HISTORY.—There is apparently only one generation a year. Overwintering adults come out in early April. Egg deposition covered rather a long period, starting late in April and continuing to the beginning of July. Eggs began to hatch the latter part of May and took from 19 to 29 days for the development of the five instars. The first generation adults were observed about the middle of June up to the beginning of August. Early in September they begin to hibernate and come out the next spring.

CONTROL.—Preliminary spray tests were applied at the Davidson orchards in Linn county. About 12 acres of these orchards were infested. So severe was the infestation that the infested trees had dropped all their leaves by July 1. The tests were applied with a wheel barrow type sprayer. Two trees were used in each test. The trees were thoroughly drenched with the spray solution. The sprays were applied on April 27.

The following sprays were applied:

No. 1.—Ammonium caseinate oil emulsion (Oil No. 6) 3%.
No. 2—Same plus Black Leaf 40, 1 to 800.
No. 3—Same plus Black Leaf 40, 1 to 600.
No. 4—Black Leaf 40, 1 to 600.
No. 5—Pyrocide 40, 1 to 800.
No. 6—Pyrocide 40, 1 to 400.
No. 7—Pyrocide 40, 1 to 400, plus oil emulsion (as used in No. 1) 3%.
No. 8—Whale oil soap 4 pounds to 50 gallons.

Tingids that were thoroughly wet with the spray were caged for observation. On most of the plots the tingids showed but little effect from the sprays. On plots 1, 7 and 8, about 50% of those wet with the spray were killed.

The tests were repeated against the nymphs of June 27, and almost 100 per cent kill was obtained with all the sprays used.

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## SOME TESTS WITH FLUORINE COMPOUNDS AGAINST THE PEPPER WEEVIL, *ANTHONOMUS EUGENII* CANO[1]

By J. C. Elmore,[2] *Bureau of Entomology, United States Department of Agriculture*[3]

### Abstract

Several fluorine compounds have been tested with respect to their insecticidal value against the pepper weevil as compared with that of calcium arsenate. Sodium fluoaluminate (synthetic cryolite), potassium fluoaluminate, and barium fluosilicate gave a higher weevil mortality than did calcium arsenate but, except in the case of potassium fluoaluminate, injury to the plants overshadowed weevil control. The injury was less pronounced in the absence of moisture or when silicon dioxide was added to the fluorine compound. Because of plant injury following treatments with fluorine compounds and the residue problem, these materials are not to be recommended as a control for the pepper weevil.

In connection with investigations of the control of the pepper weevil, a number of fluorine compounds have been tested both as to weevil mortality and as to plant injury in comparison with the effects produced by calcium arsenate and the results are presented herein simply to show the

[1]Order Coleoptera, family Curculionidae.

[2]Acknowledgments for assistance are due to S. F. Bailey and G. E. Washburn, who were detailed by the University of California to assist in the pepper weevil investigations. P. C. Ting also gave valuable assistance during the 1931 season. The author also acknowledges his indebtedness to R. E. Campbell for advice and criticisms during the progress of these investigations.

[3]All these materials except barium fluosilicate, calcium fluosilicate, and calcium arsenate were furnished by the United States Bureau of Chemistry and Soils through R. H. Carter.

comparative effect of calcium arsenate and several fluorine compounds on the pepper weevil and pepper plant.

The work of two seasons, 1931 and 1932, is reported. The ¼-acre field plots were located at Downey, Calif.; all the other experiments were carried on at Alhambra, Calif. A total of 478 experiments, in which 9,560 weevils were used, were conducted in 1931; and 180 experiments, in which 3,600 weevils were used, in 1932.

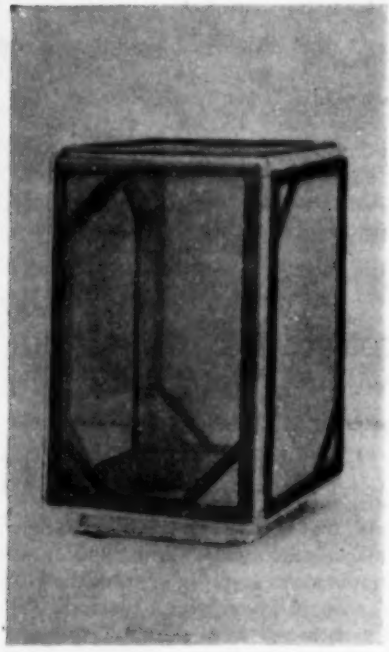

Fig. 96.—Cage used in tests of the relative effectiveness of fluorine compounds and calcium arsenate in control of the pepper weevil.

PROCEDURE, *Mortality Tests.*—For the mortality tests individual, mature pepper plants growing in an outdoor plot were first given a thorough application of the material by blowing it with a duster through a hole in a large cloth cage which could be moved from plant to plant. After the dust had settled, this cage was removed and the soil around the plant was leveled off and covered with a square of wrapping paper. A weevil-tight screened cage 14 inches square and 19 inches high, with metal flanges on the inside of the base and extending below it for about 1½ inches, was then placed over each plant. (Fig. 96.) By wrapping cotton around the stem at the ground level, sealing the slit in the square of paper, as well as the hole around the stem, with gummed paper, and pressing the edge down firmly, all weevils were prevented from escaping and dead ones could easily be detected.

Dusting was done early in the morning and the weevils were introduced after the plants had been treated. Twenty adult weevils were released in each cage immediately after treatment and observations as to weevil mortality were made at 6, 12, 24, 36, 48, and 72 hours after the applications.

In 1931 the work was begun on July 23 and continued until October 7, and in 1932 it covered the period from August 22 to September 20. In

most cases parts of each series were done on different dates and under different temperature conditions.

*Plant-Injury Tests.* To determine the effect of these compounds on the pepper plants three types of tests were conducted.

In 1931 the materials were applied to ¼-acre field plots, field methods being used, under typical field conditions.

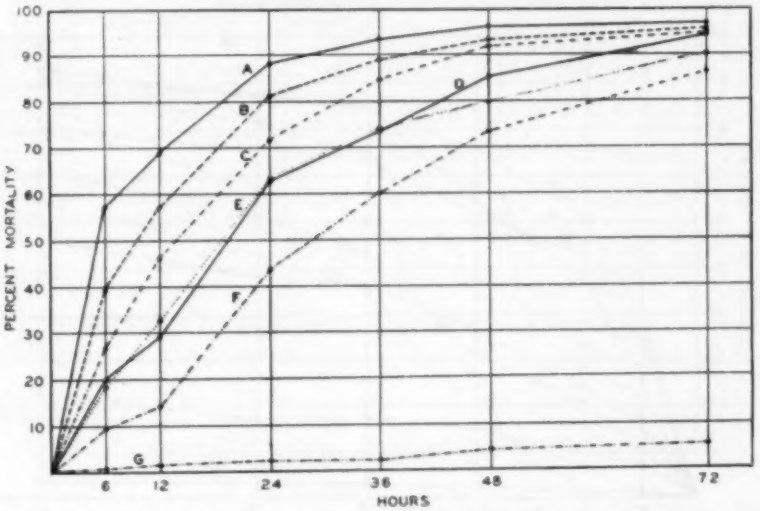


Fig. 97.—Mortality of the pepper weevil after treatments with several fluorine compounds and with calcium arsenate, experiments of 1931: (A) Sodium fluoaluminate, undiluted; (B) potassium fluoaluminate, undiluted; (C) barium fluosilicate, 80 per cent; (D) sodium fluoaluminate, 50 per cent; (E) calcium arsenate; (F) barium fluosilicate, 40 per cent; (G) untreated.

In 1932 greenhouse tests were made in which dust was applied in the same manner as in the mortality tests. Fifteen plants were treated with each material and the treatments were given every seven days from April 19 to June 9. Between May 17 and June 2 five plants in each set of 15 were wet morning and evening in order to duplicate outdoor conditions where heavy dews occur almost daily. Two dust applications were made after this wetting was begun. The results were determined by general observation and by counting the buds and pods on a given number of plants in each plot at definite intervals.

Later in the same season (July 9 to August 8) pepper pants were treated with various materials under natural outdoor conditions. Small test plots were dusted with a hand duster while long cloth panels were held on each side of the row to prevent the material from drifting to

other test plots. In this locality (southern California) the humidity is high at night and frequently moisture condenses on the plants. Since bud and pod setting has always seemed to be normal when calcium arsenate is used, this material was used as a check. The buds and pods were counted on every fifth plant in each plot on various dates. The initial count was taken as representing 100 per cent and the increase or decrease figured as percentage increase or decrease.

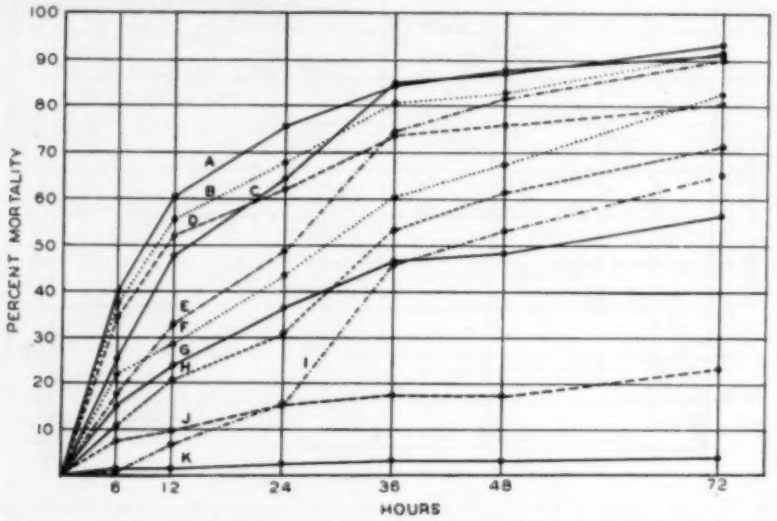


Fig. 98.—Mortality of pepper weevil safter treatments with several fluorine compounds and with calcium arsenate; experiments of 1932. (A) Potassium fluoaluminate plus silicon dioxide, 50 per cent; (B) potassium fluoaluminate, 75 per cent; (C) potassium fluoaluminate plus silicon dioxide, 75 per cent; (D) sodium fluoaluminate plus silicon dioxide, 50 per cent; (E) calcium arsenate; (F) potassium fluoaluminate, 50 per cent; (G) ammonium fluoaluminate plus silicon dioxide, 50 per cent; (H) barium fluosilicate, 50 per cent; (I) calcium fluosilicate, 50 per cent; (J) magnesium fluoaluminate, 50 per cent; (K) untreated. Talc was the diluent used in these materials.

RESULTS, *Effect of Various Compounds on the Mortality of the Pepper Weevil.*—The relative toxicity of the various fluorine compounds used and of calcium arsenate is shown in Tables 1 and 2 and Figures 97 and 98.

In 1931 sodium fluoaluminate (synthetic cryolite) showed the highest mortality and 40 per cent barium fluosilicate the lowest. (Table 1 and Figure 97.) All the materials except 40 per cent barium fluosilicate and talc caused a higher mortality than did calcium arsenate. Sodium fluoaluminate at 50 per cent, however, was slightly below calcium arsenate at the 12, 24, and 36 hour periods. Natural mortality was very

low. On plants dusted with talc the mortality was slightly lower than on untreated plants.

TABLE 1. MORTALITY OF PEPPER WEEVILS OBTAINED AT THE END OF SPECIFIED PERIODS FOLLOWING TREATMENT OF THE PLANTS WITH CALCIUM ARSENATE AND WITH SEVERAL FLUORINE COMPOUNDS. BASED ON 208 EXPERIMENTS IN 1931 IN WHICH 4,160 WEEVILS WERE USED

| Material | Number of experiments | Per cent mortality after specified number of hours | | | | | | Per cent missing |
|---|---|---|---|---|---|---|---|---|
| | | 6 | 12 | 24 | 36 | 48 | 72 | |
| Calcium arsenate | 25 | 18.4 | 32.7 | 63.4 | 74.0 | 80.0 | 90.4 | 4.0 |
| Sodium fluoaluminate, undiluted | 32 | 57.6 | 69.2 | 88.1 | 93.4 | 96.5 | 96.9 | 2.3 |
| Sodium fluoaluminate, 50 per cent; talc, 50 per cent | 27 | 20.0 | 29.4 | 63.0 | 73.5 | 85.2 | 94.4 | 2.5 |
| Potassium fluoaluminate, undiluted | 26 | 39.5 | 57.2 | 81.1 | 89.0 | 93.4 | 95.9 | 3.7 |
| Barium fluosilicate, 80 per cent; inert material, 20 per cent | 34 | 26.8 | 46.2 | 72.0 | 84.7 | 92.0 | 95.0 | 3.5 |
| Barium fluosilicate, 40 per cent; talc, 60 per cent | 34 | 9.7 | 14.0 | 43.8 | 60.0 | 75.4 | 86.3 | 4.4 |
| Talc | 8 | 1.2 | 3.1 | 3.1 | 3.1 | 3.7 | 4.3 | 0.0 |
| Untreated | 22 | 0.9 | 1.3 | 2.2 | 2.5 | 4.5 | 5.2 | 0.9 |

In the mortality tests in 1932 other fluorine compounds, as well as modifications of the same materials, were used, as indicated in Table 2

TABLE 2. MORTALITY OF PEPPER WEEVILS OBTAINED AT THE END OF SPECIFIED PERIODS FOLLOWING TREATMENTS WITH CALCIUM ARSENATE AND WITH SEVERAL FLUORINE COMPOUNDS. BASED ON 180 EXPERIMENTS IN 1932 IN WHICH 3,600 WEEVILS WERE USED

| Material | Number of experiments | Per cent mortality after specified number of hours | | | | | | Per cent missing |
|---|---|---|---|---|---|---|---|---|
| | | 6 | 12 | 24 | 36 | 48 | 72 | |
| Calcium arsenate | 14 | 17.9 | 32.5 | 48.2 | 74.3 | 81.8 | 90.0 | 3.6 |
| Potassium fluoaluminate plus silicon dioxide, 75 per cent; talc, 25 per cent | 19 | 25.5 | 47.6 | 64.5 | 85.0 | 87.1 | 93.4 | 1.8 |
| Potassium fluoaluminate plus silicon dioxide, 50 per cent; talc, 50 per cent | 22 | 40.0 | 60.2 | 75.5 | 84.5 | 87.5 | 91.1 | 2.3 |
| Potassium fluoaluminate, 75 per cent; talc, 25 per cent | 19 | 37.4 | 55.5 | 67.6 | 80.5 | 82.9 | 91.6 | 3.9 |
| Potassium fluoaluminate, 50 per cent; talc, 50 per cent | 15 | 22.0 | 28.3 | 43.0 | 60.3 | 67.3 | 82.7 | 4.7 |
| Sodium fluoaluminate plus silicon dioxide, 50 per cent; talc, 50 cent | 26 | 34.0 | 51.7 | 61.9 | 73.6 | 75.6 | 80.6 | 1.9 |
| Barium fluosilicate, 50 per cent; talc, 50 per cent | 18 | 11.7 | 20.3 | 30.8 | 53.3 | 61.4 | 71.1 | 6.9 |
| Calcium fluosilicate, 50 per cent; talc, 50 per cent | 9 | .5 | 6.6 | 15.0 | 46.1 | 53.3 | 65.0 | 2.2 |
| Ammonium fluoaluminate plus silicon dioxide, 50 per cent; talc, 50 per cent | 8 | 15.0 | 23.8 | 36.3 | 46.3 | 48.1 | 56.3 | 5.6 |
| Magnesium fluoaluminate, 50 per cent; talc, 50 per cent | 9 | 7.8 | 9.4 | 15.0 | 17.2 | 17.2 | 23.3 | 3.9 |
| Untreated | 21 | 1.4 | 1.9 | 2.4 | 3.1 | 3.3 | 3.6 | — |

and Figure 98. The data show that there was little difference in the effectiveness of the potassium and sodium compounds, but the barium, calcium, ammonium, and magnesium compounds showed a marked decrease in mortality in the order named.

*Effect of Various Materials on the Pepper Plants.* When the materials used in the mortality tests in 1931 were applied on ¼-acre field plots,

TABLE 3. RESULTS OF FIELD-PLOT TESTS WITH CALCIUM ARSENATE AND FLUORINE COMPOUNDS FOR CONTROL OF THE PEPPER WEEVIL, 1931

| Dusting material | Diluent | Number of applications[1] | Number of plots | Per cent of infestation Aug. 12[2] | Average yield of peppers, pounds per acre | Effect on plants |
|---|---|---|---|---|---|---|
| Calcium arsenate | None | 7 | 2 | 25.8 | 6,500 | No injury |
| Potassium fluoaluminate | None | 5 | – | — | — | ——— |
| Barium fluosilicate | Diatomaceous earth, 20 per cent | 2 | 3 | 20.8 | 3,800 | Light leaf burning, stunting, and bud pruning probable |
| Sodium fluoaluminate | None | 7 | 3 | 28.4 | 3,400 | Do. |
| Barium fluosilicate, 40 per cent | Diatomaceous earth 20 per cent; talc, 40 per cent | 7 | 2 | 30.0 | 2,200 | Leaf burning, stunting, and bud pruning light |
| Barium fluosilicate, 80 per cent | Diatomaceous earth, 20 per cent | 7 | 2 | 11.7 | 1,800 | Severe leaf burning, plants stunted and yellow, fruit odd-shaped and small |
| Untreated | ——— | – | 4 | 48.2 | 1,200 | ——— |

[1]Made weekly, beginning July 22, 1931.
[2]Obtained by counting all buds and pods on 30 plants in each plot.

there was little change in effectiveness in reducing infestation. (Table 3.) Plant injury, however, overshadowed weevil control. Barium fluosilicate not only burned the leaves, but stunted the plants and very noticeably reduced the crop. Pods were off type in size, shape, and color. Sodium fluoaluminate caused slight leaf burning and some crop reduction. There was not enough potassium fluoaluminate used that year to determine its effect on the plants. With calcium arsenate, although the mortality was not so high as with some of the fluorine compounds, the yield of peppers was by far the highest. This was thought to be due to the fact that the fluorine dusts reduced pod setting.

In the tests in 1932 which were conducted in the greenhouse, the bud and pod counts varied so much that they were of no value in showing

comparative injury. General observations as to the condition of the plants after the treatments with each material are shown in Table 4,

TABLE 4. INJURY TO PEPPER PLANTS CAUSED BY CALCIUM ARSENATE AND FLUORINE COMPOUNDS; EXPERIMENTS OF 1932 CONDUCTED IN THE GREENHOUSE

| Material | Number of plants | Number of applications on Dry foliage | Number of applications on Wet foliage | Injury |
|---|---|---|---|---|
| Barium fluosilicate, 50 per cent | 10 | 7 | – | Slight; yellow spots on leaves, buds damaged slightly. |
| | 5 | 5 | 2 | Pronounced; leaves yellow and burned, buds damaged. |
| Sodium fluoaluminate, 50 per cent | 10 | 7 | – | None. |
| | 5 | 5 | 2 | Pronounced; leaves yellow, buds damaged. |
| Ammonium fluoaluminate plus silicon dioxide, 50 per cent | 10 | 7 | – | Slight. |
| | 5 | 5 | 2 | Slight but definite, typical leaf and bud damage. |
| Sodium fluoaluminate, 50 per cent | 10 | 7 | – | None. |
| | 5 | 2 | 2 | Slight injury to leaves; bud injury doubtful. |
| Magnesium fluoaluminate, 50 per cent | 10 | 7 | – | None. |
| | 5 | 5 | 2 | Slight leaf yellowing only. |
| Potassium fluoaluminate plus silicon dioxide, 50 per cent | 10 | 7 | – | None. |
| | 5 | 5 | 2 | Slight bud pruning and leaf yellowing. |
| Calcium fluosilicate, 50 per cent | 10 | 7 | – | None. |
| | 5 | 5 | 2 | Slight bud pruning and leaf yellowing. |
| Calcium arsenate | 10 | 7 | – | None. |
| | 5 | 5 | 2 | None. |
| Talc, 50 per cent; diatomaceous earth, 50 per cent | 10 | 7 | – | None. |
| | 5 | 5 | 2 | None. |
| Untreated | 10 | – | – | None. |
| | 5 | – | – | None. |

however. The observations were made without knowledge as to the kind of treatment the plant received.

In the tests conducted in the field in 1932 the appearance of the plants checked favorably with the bud and pod counts. (Table 5 and Fig. 99.) The plants treated with the 1931 sample of barium fluosilicate were severely burned. The plants treated with sodium fluoaluminate showed

definite bud and foliage injury for several days after the last treatment, and then apparently began to recover and to set buds rapidly. The 1932

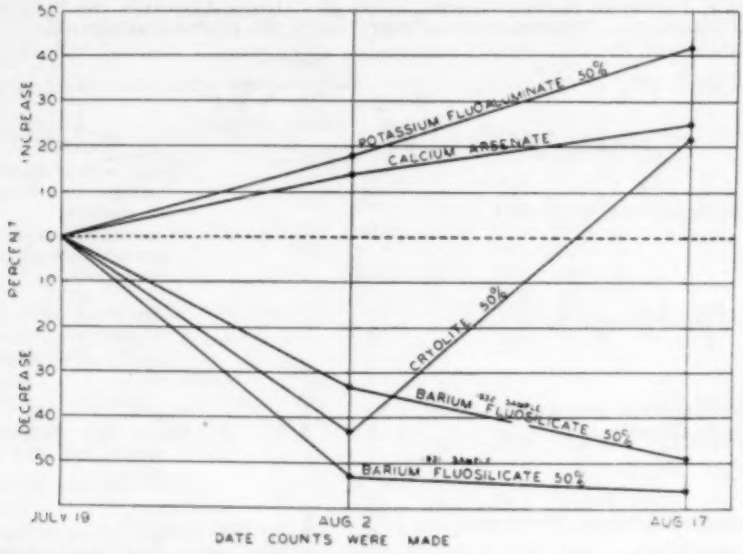


Fig. 99.—Effect of several fluorine compounds as compared with calcium arsenate on the bud and pod setting of pepper plants.

sample of barium fluosilicate showed less pronounced but definite injury. Potassium fluoaluminate showed no injury of any kind either here or in field plots in four different areas.

TABLE 5. EFFECT OF FLUORINE COMPOUNDS AND CALCIUM ARSENATE ON BUD AND POD SETTING OF PEPPER PLANTS WHEN TREATMENTS WERE GIVEN UNDER OUTDOOR CONDITIONS, 1932

| Material | Treatment dates | Number of treatments | Total number of buds and pods on 10 plants in each plot | | | Percentage increase of buds and pods | |
|---|---|---|---|---|---|---|---|
| | | | July 19 | Aug. 2 | Aug. 17 | Aug. 2 | Aug. 17 |
| Calcium arsenate | July 9, 16, 23, August 1, 8 | 5 | 911 | 1,044 | 1,147 | +14 | +25 |
| Potassium fluoaluminate, 50 per cent | July 9, 16, 23, August 1, 8 | 5 | 864 | 1,023 | 1,225 | +18 | +42 |
| Sodium fluoaluminate (Cryolite), 50 per cent | July 9, 16, 23, August 1, 8 | 5 | 987 | 560 | 1,204 | —43 | +22 |
| Barium fluosilicate, 50 per cent: 1932 sample | July 23, Aug. 1, 8 | 3 | 1,250 | 838 | 637 | —32 | —49 |
| 1931 sample | July 23, Aug. 1, 8 | 3 | 794 | 376 | 355 | —53 | —56 |

RELATIVE EFFECTIVENESS OF SINGLE AND DOUBLE TREATMENTS.—It was frequently noticed that materials that were giving good results in experimental plots, with thorough applications, were not controlling the weevils when used by growers. A study of dusting methods showed that the laborers usually employed for this work were doing it in a careless manner. Hand dusters of the crank type were employed largely. Usually the nozzle was carried so near the tops of the plants that a heavy application was being made down the center of the row whereas the outer branches were untouched.

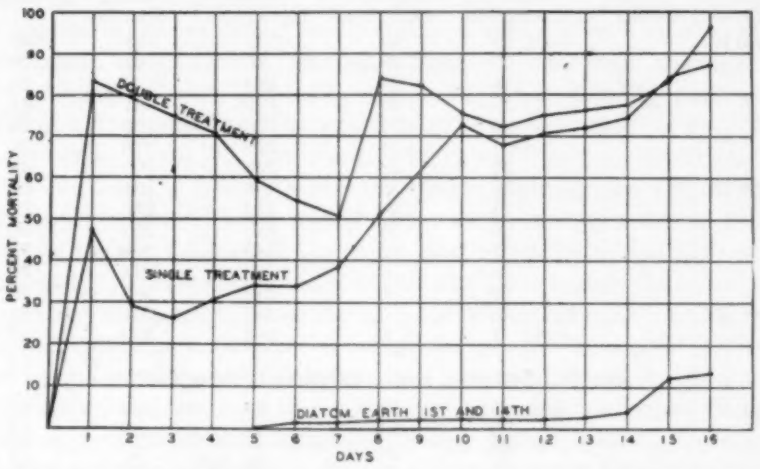


Fig. 100.—Mortality of the pepper weevil resulting from single and double treatments with a mixture of 70 per cent sodium fluoaluminate, 25 per cent diatomaceous earth, and 5 per cent hydrated lime, and with diatomaceous earth alone.

In order to determine if the method of dusting had any influence on the effectiveness of the treatments, two series of cages were set up. In one series 19 plants were given a single treatment in the manner just described, and in the other 12 plants were dusted first on one side of the row and then on the other. A mixture of 70 per cent sodium fluoaluminate, 25 per cent diatomaceous earth, and 5 per cent hydrated lime[4] was used as the dusting material. About 8 pounds per acre were put on in the first case and 16 pounds in the second. Applications were made at 7-day intervals, and two weevils were introduced in each cage each day for 10 days to represent a continuous reinfestation. As a check five plants

[4]Lime was added to determine if it would reduce the effectiveness of sodium fluoaluminate.

were treated with undiluted diatomaceous earth on the first and fourteenth days and three were left untreated.

The results of this experiment are shown in Figure 100 and, for the treatments with the sodium fluoaluminate mixture, in Table 6. It will

TABLE 6. SUMMARY OF RESULTS OF SINGLE AND DOUBLE TREATMENTS WITH A MIXTURE OF 70 PER CENT SODIUM FLUOALUMINATE, 25 PER CENT DIATOMACEOUS EARTH, AND 5 PER CENT HYDRATED LIME

| Date of dusting | Date of weevil introduction | Number of weevils introduced each day | Total number of weevils introduced | Total number of dead weevils | Per cent mortality[1] |
|---|---|---|---|---|---|
| **Single treatments, results based on 19 experiments** | | | | | |
| Sept. 16 | Sept. 16 | 38 | 38 | 18 | 47 |
| | 17 | 38 | 76 | 22 | 29 |
| | 18 | 38 | 114 | 30 | 26 |
| | 19 | 38 | 152 | 47 | 31 |
| | 20 | 38 | 190 | 65 | 34 |
| | 21 | 38 | 228 | 78 | 34 |
| | 22 | 38 | 266 | 102 | 38 |
| Sept. 23 | 23 | 38 | 304 | 204 | 67 |
| | 24 | 38 | 342 | 250 | 73 |
| | 26 | 38 | 380 | 258 | 68 |
| | 27 | 0 | 380 | 268 | 71 |
| | 28 | 0 | 380 | 274 | 72 |
| | 29 | 0 | 380 | 283 | 74 |
| Sept. 30 | 30 | 0 | 380 | 321 | 84 |
| | Oct. 1 | 0 | 380 | 332 | 87 |
| **Double treatments, results based on 12 experiments** | | | | | |
| Sept. 23 | Sept. 23 | 24 | 24 | 20 | 83 |
| | 24 | 24 | 48 | 36 | 75 |
| | 26 | 24 | 72 | 51 | 71 |
| | 27 | 24 | 96 | 57 | 59 |
| | 28 | 24 | 120 | 65 | 54 |
| | 29 | 24 | 144 | 73 | 51 |
| Sept. 30 | 30 | 24 | 168 | 142 | 84 |
| | Oct. 1 | 24 | 192 | 158 | 82 |
| | 2 | 24 | 216 | 163 | 75 |
| | 3 | 24 | 240 | 175 | 73 |
| | 4 | 0 | 240 | 181 | 75 |
| | 5 | 0 | 240 | 184 | 77 |
| | 6 | 0 | 240 | 186 | 78 |
| Oct. 7 | 7 | 0 | 240 | 201 | 84 |
| | 8 | 0 | 240 | 231 | 96 |

[1]The per cent mortality was determined by comparing the total number of weevils dead on each date with the total number that had been introduced.

be noted that with the double treatment the mortality curve was well above 50 per cent while with the single treatment it remained below that point until after the second application on the seventh day. Close observations indicated that this was largely because the double treatment gave a thorough covering of all the foliage. After the tenth day, and especially after the third application on the fourteenth day, the

mortality in both cases approached 100 per cent, probably because no weevils were introduced after the tenth day. Diatomaceous earth caused some killing, but it was more pronounced after the second application on the fourteenth day, when the weevils were dusted as well as the plant. The natural mortality on untreated plants (not shown in the chart) was only 1.5 per cent on the eleventh day and 3.3 per cent at the close of the experiment.

SUMMARY.—Sodium fluoaluminate, potassium fluoaluminate, and barium fluosilicate at dilutions as low as 50 per cent and calcium arsenate at full strength were all found to be effective against the pepper weevil when applied under controlled cage conditions with a known number of adult weevils. Sodium and potassium fluoaluminates were the most effective materials used. Barium fluosilicate, while showing marked effectiveness at concentrated strengths in 1931, gave rather low results when diluted to 50 per cent. Although effective as a weevil control, this material not only burned the leaves but caused stunting and yellowing of the pepper plants. Plants dusted with sodium fluoaluminate in the presence of moisture exhibited leaf injury and bud pruning but did not appear unusually yellow or retarded in growth. Both barium fluosilicate and sodium fluoaluminate caused crop reduction in field plots in 1931. Of the fluorine compounds found to be satisfactory for the control of the pepper weevil, potassium fluoaluminate was the least toxic to the plants.

In the absence of moisture under greenhouse conditions barium fluosilicate was the only fluorine compound causing definite injury. Sodium and potassium fluoaluminate samples containing small quantities of silicon dioxide caused less injury in the greenhouse on wet plants than did the unmodified sodium fluoaluminate.

A series of experiments in which one group of plants was doubly treated, once down each side of the row, and another group was dusted down the center of the row showed that an effective insecticide carelessly applied in the field may not cause so high mortality of the weevils as a less effective material more carefully applied.

The results of this work bring out the fact that fluorine compounds are injurious to pepper plants, and because of this and also the residue problem they are not to be recommended as a control for the pepper weevil.

# EFFICIENT AGITATION IN THE SPRAY TANK

By ARTHUR D. BORDEN, *Assistant Entomologist, University of California*

ABSTRACT

In testing over 200 spray outfits the agitation in the spray tank was found to be decidedly inefficient. The propeller type agitators at speeds less than 200 rpm do not give a uniform mixture. A new type square end agitator gives excellent results at speeds from 88 to 110 rpm and a low hp consumption. It is recommended that this type of agitator replace the propeller type.

The agitation in the standard spray equipment is decidedly inefficient. In testing over 200 spray outfits, including such makes as the Bean, Hardie, Hayes, Myers and Friend, very few have given a uniform mixture of the insecticides used. With the propeller type of agitators with which most of these outfits are equipped the rpm of the agitator shaft is by far too low to give efficient results. Even in those using the larger type of blades such as the Bean and Hardie, the practice of having only two such agitators in a 200 gallon tank or three in a 300 gallon tank at a speed of from 86 to 120 rpm, does not produce a uniform mixture throughout the delivery from the pump. The last fifty gallons of spray often have a concentration of from ten to twenty times that delivered when the tank is full.

The matter of uniformity of mixture is most important in the tank mixture method of preparing oil sprays and also of considerable importance in the application of such materials as lead arsenate, sulfur and the heavier types of commercial oil emulsions. Too frequently do we find that the last few trees sprayed with the last of the spray from a tank of lead arsenate receive a much heavier deposit of lead arsenate than do the trees sprayed with the first fifty gallons from the same tank. This not only affects the efficiency of the coverage from the standpoint of toxicity but also may greatly affect the residue removal problem, especially on the fruit receiving an excess deposit due to improper concentration.

This matter of efficient agitation was first developed by Dr. Ralph Smith in his work with the tank mixture method of spraying citrus in southern California (Bulletin 527, University of California). He has shown that a uniform mixture may be obtained with either four of the small type Hardie, two of the large Hardie or 2–3 bladed Bean agitators in a 200 gallon tank if 200 rpm are developed on the agitator shaft. With these propeller type agitators speed of agitation is more essential than the increase in number of agitators used. This combination required about .5 hp which is relatively negligible in the case of motors of

8 hp and above. By simply changing the gear ratio between pump and agitator shaft the desired speed can be obtained.

In developing the tank mixture method of oil spraying on deciduous fruits in northern California, the writer has found that this increased speed with the demand for additional energy is often difficult to obtain. Much of our equipment has comparatively low powered motors (2.5 to 8 hp) with 200 and 300 gallon tanks and it is with difficulty that 300 lbs. pressure can be maintained when both lines of hose are operating. To further tax the motor with this high speed agitation is often impossible. Furthermore it is often difficult and expensive to obtain the desired gears for the change over.

A new type of agitator has made it possible to obtain the desired uniform mixture without increasing the speed of the agitator shaft and using but a minimum amount of energy. This agitator is a 2 bladed, flat square end piece of $\frac{3}{16}$ inch steel with the following dimensions:

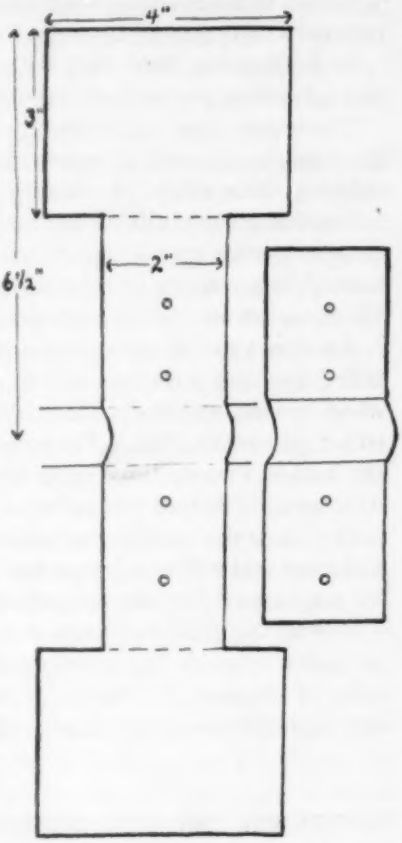


FIG. 101.—Pattern of flat square end propeller.

| | |
|---|---|
| Length over all | 13 inches |
| Shank | 2 inches wide |
| Groove to fit shaft | 1 inch |
| End plates at right angles to shank | 3 x 4 inches |
| Binding plate with groove for shaft and four $\frac{3}{8}$ inch bolt holes | 2 x 6 inches |

The end plates may be made any desired length (4″–6″–8″) from 3″ material and are best welded to the ends of shank.

Tests conducted in the laboratories of the Agricultural Engineering Division at Davis have shown that in a 200 gallon Hardie tank uniform mixtures were obtained with four of these 3″ x 4″ agitators at 88 rpm, with but a .2 hp consumption. Adding two of these flat square end

agitators to 2 large Hardie agitators already in the tank gave a uniform mixture at 109 rpm with less than .2 hp consumption.

In a 300 gallon Bean tank with 3–3 bladed Bean and 4–3″ x 8″ square end agitators a perfect test was obtained at 96 rpm.

These new type agitators may be made on the ranch or by a local blacksmith at a cost of approximately half of the other type and considering their efficiency should replace all other types of agitators.

In some spray tanks the agitator shaft is too close to the bottom of the tank to permit any adequate type of agitator to be applied. In such cases it is necessary to raise the shaft so as to permit at least 7½ inch clearance between shaft and bottom of tank.

Another type of agitator has also proven very efficient. It may be called the 'reel' type and is composed of two 1½ inch strips of steel or wood spaced within clearance distance of the bottom of the tank on either side of the shaft. The length of these strips is the inside length of the tank. Two or three cross members bind these strips to the shaft. At a speed of 96 rpm this agitator gave a perfect test in a 200 gal. Hardie tank. In tanks having overhead suction system or rods to strainer, the reel must end within a few inches of such device and a square end agitator can be used between the end of tank and suction line or rod.

Due to the greater efficiency of the flat square end agitators over the propeller type, it is recommended that for efficiency the new type agitator displace all others. It is better to have a complete set of the new type than to mix them with the less efficient propeller type.

## NOTES ON THE LIFE HISTORY OF THE APPLE MAGGOT IN WISCONSIN

By T. C. Allen and C. L. Fluke, Jr.*

Abstract

Studies of the seasonal emergence of the apple maggot (*Rhagoletis pomonella*) during 1932 showed that over 37 per cent of the flies emerged from two-year old pupae. The peak of the emergence of these flies occurred eight days later than the normal brood which affected timing of sprays. Yeasts dried at 70–80° F., powdered and mixed with 3 or 4 parts of honey proved considerably more successful for rearing the adult fly than did yeast and honey when water was added.

During studies of the life history of the apple maggot at Gays Mills, Wisconsin, it was noted that a relatively large brood of flies emerged in

*Published with the approval of the Director of the Wisconsin Agricultural Experiment Station.

1932 from two-year old pupae. These flies emerged later than flies which spent one winter in the soil and showed a distinct peak of emergence comparable to a second brood of adults. The late emergence of flies from these two-year pupae accounted for the late appearance of many flies in the orchard.

A number of workers have reported a two year cycle of the apple maggot. Their observations indicate that a small per cent of the flies ordinarily require two seasons to complete their life cycle. Lathrop and Nickels[1] found a two and a three season carry-over of flies in studies of the blueberry maggot recently described as *Rhagoletis mendax* by Curran[2] which emerged later than flies that spent only one season in the soil. These workers noted that the carry-over of flies in one instance amounted to 19.68 per cent. Studies on the apple maggot under Wisconsin conditions have shown a maximum of 37 per cent carry-over for two years. The fact that a large proportion of the apple maggot-flies may not emerge until a second season is significant in the control of this insect.

Apple maggot adults which emerge from pupae that remain in the soil for a period of two seasons are of an economic importance at Gays Mills, Wisconsin. A distinct emergence peak of such flies occurring later in the season than normally obviously affects a spray program designated for earlier emerging insects. Two sprays, one for each brood of flies, have been therefore recommended in seasons of a heavy carry-over. The first spray is applied before the peak of the normal emerging flies has been reached. The second spray is applied previous to the peak of the carry-over brood which occurs 8 to 12 days later. Lead arsenate at the rate of one pound to fifty gallons of lime sulfur spray, when applied as suggested above, controlled the apple maggot.

METHODS AND RESULTS.—The time of emergence of maggot-flies was determined by the usual method, by making daily counts of emerging flies from overwintering hibernation cages. The cages used in 1929 were made of wooden frames of 1 by 8 inch boards, 3 feet wide, and 10 feet long and were set securely on the surface of the soil. The tops of these frames were enclosed with wire screening, except for a small opening to which was attached a smaller wire cage to collect the flies. A black paper covering placed over the frames for a brief interval before

[1]Lathrop, F. H. and Nickels, C. B. 1932. The Biology and Control of the Blueberry maggot in Washington County. U. S. D. A. Bur. Ent. Tech. Bull. 275, pp. 1–77.

[2]Curran, C. H. 1932. North American Diptera, With Notes on Others. Amer. Mus. Novitates No. 526, pp. 1–13.

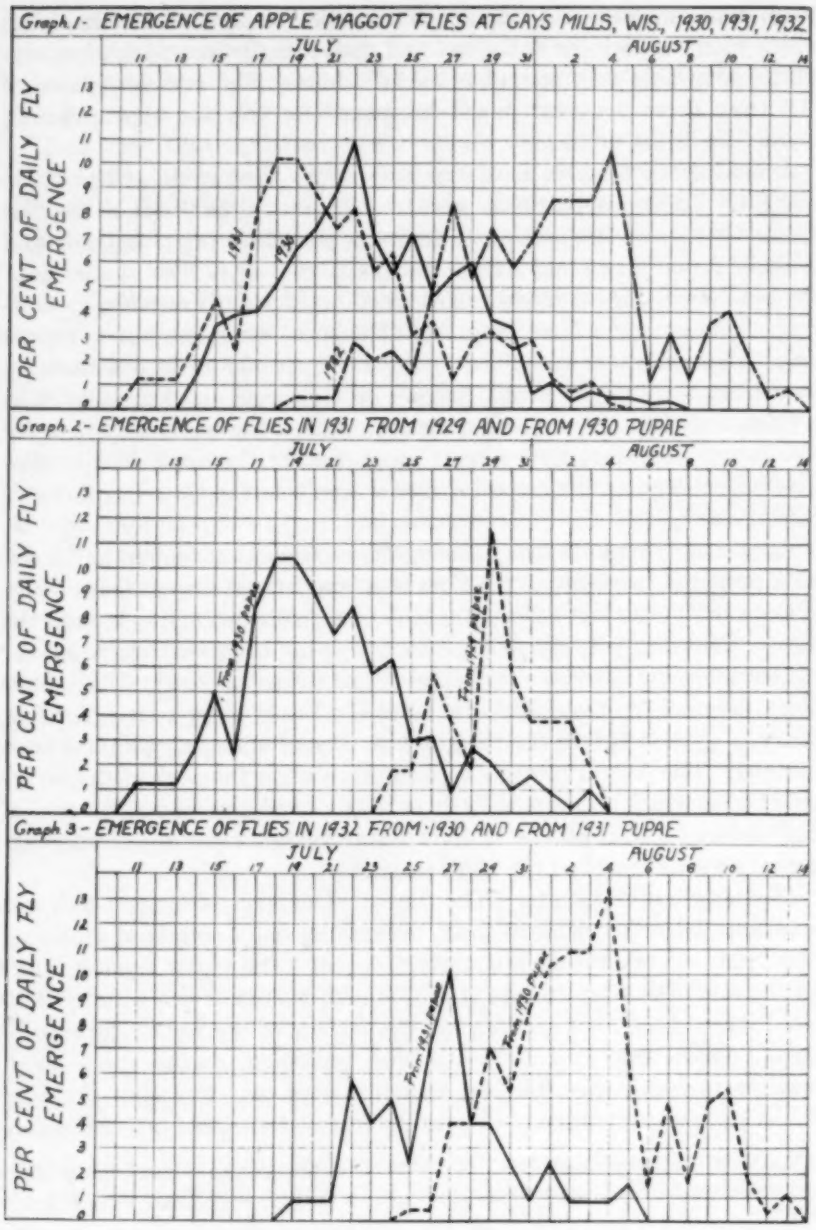
Graph 1- EMERGENCE OF APPLE MAGGOT FLIES AT GAYS MILLS, WIS., 1930, 1931, 1932
JULY
AUGUST
PER CENT OF DAILY FLY EMERGENCE
1931
1930
1932
Graph 2- EMERGENCE OF FLIES IN 1931 FROM 1929 AND FROM 1930 PUPAE
JULY
AUGUST
PER CENT OF DAILY FLY EMERGENCE
From 1930 Pupae
From 1929 Pupae
Graph 3- EMERGENCE OF FLIES IN 1932 FROM 1930 AND FROM 1931 PUPAE
JULY
AUGUST
PER CENT OF DAILY FLY EMERGENCE
From 1931 Pupae
From 1930 Pupae

FIG. 102.—Apple maggot emergence.

collecting aided in inducing the flies to enter the smaller cages. The cages were located in the orchard where they were partly shaded by apple trees and approximately six bushels of several varieties of maggot-infested apples were put in each cage.

A larger number of cages were employed in 1930 and 1931. Nineteen cages, 2 by 3 feet in size were used. They were constructed similar to those described above and were placed in the orchard at various locations under the trees. Each of these cages contained only one variety of maggot-infested fruits and were prepared as each variety matured. All cages were enclosed with wire screening and since no infestation of apple maggot occurred in the immediate vicinity of the cages, it was assumed that no maggots or maggot infested fruit entered the cages to affect the results.

The accompanying graphs in figure 102, show the daily emergence in per cent of 13,680 flies over a period of three seasons. Graph 1 represents the total seasonal adults taken from hibernation cages in 1930, 1931 and 1932. In graph 2, a comparison is made of the emergence of one year and of two year carry-over flies. Slightly more than 7 per cent of the flies from 1929 pupae emerged in 1931. Their emergence however, showed a peak which occurred 11 days later in the season than the peak of the one year flies. The percentage carry-over this season is not of considerable significance. Graph 3 compares the emergence of flies in 1932 from one and from two year old pupae. The collections of flies in 1932 showed that 37 per cent of the adults from 1930 pupae emerged in 1932. The emergence peak of this season's carry-over occurred 8 days later than the one year brood.

The large two-year brood of apple maggots in 1932 at Gays Mills had emerged from pupae that remained in the soil during the hot and dry summer of 1931. This abnormally warm season in the absence of much moisture at time of fly emergence undoubtedly accounted for such delayed emergence. During this season, infestation of the apple maggot was also noted to be relatively light. The flies that had emerged were observed to be affected considerably from the heat and lack of moisture. They succumbed readily both in the insectary and under natural conditions in the orchard. The ability of the apple maggot to remain in the soil during seasons of unfavorable conditions has an important bearing upon the survival of the species.

IMPROVED REARING MIXTURE.—The use of honey-water and yeast as a food in rearing the apple maggot[3] has given more favorable results

[3]Fluke, C. L. and Allen, T. C. 1931. The Role of yeast in life history studies of the Apple Maggot, *Rhagoletis pomonella* Walsh. Jr. Ec. Ent. 24: 1, pp. 77–80.

when the water is omitted. Flies fed ravishly upon honey to which four parts of powdered dead yeast cells were added, and gravid females developed as early as 9 days. Copulation occurred as late as 76 days. Red Star yeast dried at 70 to 80 degrees F. and powdered and mixed with honey furnishes considerably more protein material when water is absent since fermentation is prevented. A smear of this mixture upon the sides of the container in which flies are reared, remains several days and will not ferment unless diluted with water. Water is necessary however, and was supplied to the containers separately twice daily. Lamp chimneys in which were placed apples for oviposition served as rearing cages, and two broods of this insect were reared in the laboratory during December, January and February.

## FIELD STUDIES WITH PINE OILS AS DESTROYERS OF OVERWINTERING CODLING MOTH LARVAE[1]

By F. M. THOMPSON, Jr. *Research Assistant, Rutgers University*
and
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ABSTRACT

A blend of various fractions of steam-distilled pine oils was found to be effective in field applications against hibernating codling moth larvae (*Carpocapsa pomonella*) when brushed liberally upon the rough bark, crotches, pruning wounds, and cankers of apple trees. The applications produced marked reduction in the amount of first brood codling moth injury in the treated blocks, without injury to the trees. Fruit counts at harvest indicated that the initial advantage gained by the treatment will produce the greatest benefit when large areas are treated at the same time, and followed by the recommended codling moth cover sprays.

In the fall of 1930 a study of the various steam-distilled pine oils was undertaken in an attempt to develop a spray which would be effective in killing codling moth larvae overwintering on the trunks of apple trees. An efficient formula was developed, but the mixture proved to be injurious to apple buds. When diluted with equal parts of water it could be brushed onto the rough-barked areas of the trunk and larger limbs,

[1]Paper of the Journal Series, New Jersey Agricultural Experiment Stations, Department of Entomology.

Publication authorized by the Director of the Pennsylvania Agricultural Experiment Station as Technical Paper No. 574.

[2]The preliminary investigation leading to the development of the formula was the work of the senior author, who also planned and supervised the field tests in New Jersey. The field test in Pennsylvania was planned by the junior author, and supervised by both. The fruit counts and the preparation of this paper were done jointly.

but it was imperfectly miscible, and was abandoned in favor of the idea of developing a paint that could be applied to the trunks in a concentrated form.

Considerable time was spent in the search for fractions of pine oil which could be used on the trunks of the trees without injury, but which would at the same time be toxic to codling moth larvae. When these fractions were found, it was necessary to blend them into a mixture possessing the desired physical properties. Finally a formula was developed which consisted of a blend of several fractions, with a heavy non-volatile oil as a base. The trade name HYBREX has been given to this material, and will be used for convenience in this paper.

The physical properties of "Hybrex" are such as to allow it to be applied with a brush to those parts of an apple tree that shelter the great majority of codling moth larvae; e. g., the rough-barked areas of the trunk and limbs, narrow crotches, split limbs, cankers, old pruning scars, etc. When applied with thoroughness and in sufficient quantity it runs beneath the bark scales, and penetrates into cracks and rotting stubs. Codling moth cocoons soak it up readily, and the larvae are killed on contact. It is the purpose of this paper to present the results of block treatments with this material during 1932.

METHODS.—In the spring of 1932 arrangements were made to "oil" the trunks of several hundred apple trees in an orchard near Glassboro, New Jersey. Four blocks were laid out in this orchard, as follows:

Block 1. Stayman—32 rows of 14 trees each.
- 8 rows untreated.
- 8 rows scraped and banded.
- 8 rows "oiled" with "Hybrex".
- 8 rows untreated.

Block 2. Winesap—24 rows of 14 trees each.
- 8 rows untreated.
- 8 rows scraped and banded.
- 8 rows "oiled" with "Hybrex".

Block 3. Rome Beauty—100 trees, 10 x 10.
- 42 trees (7 x 6) at the center "oiled" with "Hybrex". Remainder of trees untreated.

Block 4. Mixed varieties—100 trees, triangular planting.
- Half the block untreated.
- Half the block "oiled" with "Hybrex".

A fifth block was laid out in an orchard at McKnightstown, Adams County, Pennsylvania.

Block 5. York Imperial—30 rows of 15 trees each.
- 15 rows untreated.
- 15 rows "oiled" with "Hybrex".

In blocks 1 to 4 the oiling was done in April, when the trees were in the "pink-bud" stage. The trees in the Glassboro orchard were 15–18 years old. Those in block 3 had developed little rough bark, so that it was not necessary to use much oil except in the crotches and on pruning scars and cankers in the tops of the trees. The oil was applied by means of a round brush about 3 inches in diameter, with bristles 2–3 inches long, mounted at an angle on the end of a broomstick. The banded rows were scraped in the spring, and the scrapings burned. Bands were applied in June.

In block 5 the oiling was done May 4 to 6, when the trees were in full bloom. The trees in the Pennsylvania orchard were 25–30 years old. They presented large areas of rough bark, many pruning stubs, and cankers caused by egg-laying punctures of the periodical cicada. The treatment in this block required an average of 3 pints of oil per tree, and took 20 minutes per tree to apply. The operation is illustrated on plate 55, figures 1 and 2.

RESULTS.—Several oiled and untreated trees in the Glassboro orchard were carefully examined by the senior author a few days after the application. Living and dead larvae were recorded. The data are set forth in Table 1.

TABLE 1. EFFECT OF "HYBREX" ON HIBERNATING CODLING MOTH LARVAE. GLASSBORO, N. J., 1932

| Treatment | Number trees examined | Number larvae found | Number larvae dead | Per cent larvae dead |
|---|---|---|---|---|
| Hybrex[1] | 2 | 118 | 113 | 95.8 |
| Hybrex[2] | 9 | 181 | 107 | 59.1 |
| Untreated | 8 | 118 | 32 | 27.1 |

[1]Trees treated by senior author.
[2]Trees treated by inexperienced laborers.

Table 1 clearly shows the effectiveness of the treatment, and also the need for thoroughness and good judgment in its application. No more time nor material were expended to procure the higher kill. The workmen employed were simply inexperienced in orchard operations, and knew little or nothing about the codling moth and its habits.

No detailed examination of trees was made in the Pennsylvania orchard. The men employed here were experienced orchard hands, familiar with the hiding places of codling moth larvae. In checking

EXPLANATION FOR PLATE 55.

1—The "brush" method of treating apple trees to kill hibernating codling moth larvae.

2—Apple trunk and pruning stubs after brush treatment with pine oil blend.

3—Codling moth larvae killed in their cocoons by pine oil treatment.

1 2 3

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back over their work few living larvae were found. Several of the dead larvae are pictured on plate 55, figure 3.

The toxicity of "Hybrex" to codling moth larvae had been determined by the investigation upon which the formula was based, and was confirmed by the field counts reported in Table 1. The main purpose of the block treatments was to discover the effect on the fruit of the reduction in codling moth population obtained by such pre-season treatment. Any reduction in population should produce a reduction in the number of codling moth injuries, particularly those produced by the first brood of larvae. Drift of first brood moths into treated blocks would tend to obscure the results. Accordingly, the first fruit counts were made after the attack of the first brood larvae had ceased, but before many second brood larvae had hatched.

In the New Jersey orchard three trees were selected at the center of each treatment. One hundred apples from the top and 100 from the bottom of each tree were scored for codling moth injury. In the Pennsylvania orchard 5 trees at the center of each treatment were used, and 50 apples from the upper and 50 from the lower branches were examined. Table 2 presents the results of these counts.

TABLE 2. INJURY BY FIRST BROOD CODLING MOTH LARVAE IN TEST BLOCKS

| | Treatment | Number of apples Counted | Injured | Per cent Injured | Injuries Total Per cent | Reduction |
|---|---|---|---|---|---|---|
| Block 1 | Untreated | 600 | 292 | 48.6 | 611 | — |
| | Scraped | 600 | 258 | 43.0 | 470 | 19.9 |
| | Hybrex | 600 | 236 | 39.3 | 382 | 34.9 |
| | Untreated | 600 | 278 | 46.3 | 563 | — |
| Block 2 | Untreated | 600 | 249 | 41.5 | 506 | — |
| | Scraped | 600 | 174 | 29.0 | 246 | 51.4 |
| | Hybrex | 600 | 130 | 21.6 | 170 | 66.4 |
| Block 3 | Untreated | 600 | 187 | 31.1 | 371 | — |
| | Hybrex | 600 | 103 | 17.1 | 131 | 64.7 |
| Block 4 | Untreated | 600 | 213 | 35.5 | 337 | — |
| | Hybrex | 600 | 180 | 30.0 | 233 | 30.9 |
| Block 5 | Untreated | 500 | 271 | 54.2 | 556 | — |
| | Hybrex | 500 | 192 | 38.4 | 315 | 43.3 |

The infestation figures in Table 2 would have been much lower in all blocks had recommended spraying practices been followed. Spraying practices were uniform in the blocks under comparison, but in both orchards the timing was poor and important cover sprays were omitted. In addition, block 5 received only about one-fourth the recommended amount of spray material per tree per application. However, as the

table clearly shows, the pre-season treatments given were of considerable value in reducing the number of injuries to the fruit, even in the comparatively small blocks of trees used.

Fruit counts were made at picking time only in blocks 2 and 5. Block 1 had such a light set that in the absence of adequate spraying treatment all the fruit was injured. The treated portion of block 3 was so small that moth migration during the summer obscured the earlier beneficial results. Due to a mistake, block 4 was picked before counts had been made.

Harvest counts were made on the trees used earlier in the season. In block 2, 100 apples were taken from the top of each tree, 100 from the bottom, and 25 dropped fruit from the ground. In block 5, 50 apples were taken from the top, 50 from the bottom, and 50 from the ground. In both orchards the dropped fruit was included in the counts in their estimated proportion to the total crop. The results of these counts are shown in Table 3.

TABLE 3. CODLING MOTH INJURY IN TEST BLOCKS AT HARVEST

| | Treatment | Number of apples Counted | Clean | Per cent Clean | Injuries Total Per cent | Reduction |
|---|---|---|---|---|---|---|
| Block 2 | Untreated | 675 | 69 | 10.2 | 2,782 | — |
| | Scraped and banded | 675 | 254 | 37.6 | 915 | 67.1 |
| | Hybrex | 675 | 263 | 38.9 | 918 | 67.0 |
| Block 5 | Untreated | 750 | 179 | 23.8 | 1,418 | — |
| | Hybrex | 750 | 228 | 30.4 | 1,144 | 19.3 |

By comparing Tables 2 and 3 it will be noticed that in block 2 the section treated with "Hybrex" maintained the advantage gained earlier in the season, and that the banding improved the total effect of the scraped section by preventing heavy emergence of first brood moths. These two treatments showed almost identical results by the end of the season.

In block 5, however, the early season advantage indicated in Table 2 was largely lost by picking time. This result was expected. It was due to poor spraying practices which allowed a high proportion of the first brood larvae to develop. Stimulated by a poor set of fruit, many first brood moths migrated into the oiled section from heavily infested blocks on three sides. It seems obvious that the greatest benefit can be derived from the pine oil treatment only when all badly-infested blocks in a given orchard area are treated in the same year, and the treatment followed by the recommended program of codling moth cover sprays.

During the time of treatment, "Hybrex" was applied to the following varieties: Rome Beauty, Stayman Winesap, Winesap, York Imperial,

King David, Gano, Early Ripe, Paragon, and Maiden Blush. Some of these trees have had applications in two successive years, but in no case has any injury from the use of this material appeared. It is felt certain that one application of the oil will cause no damage. It should not be applied to new pruning wounds, for the tissue will be killed back. It is also injurious to the buds.

SUMMARY AND CONCLUSIONS.—A blend of steam-distilled pine oil fractions named "Hybrex" was effective in reducing codling moth population in apple orchards when thoroughly painted on the areas of rough bark, crotches, pruning scars and cankers. These areas must be *thoroughly wet* with the material. It may be applied with a long-handled brush, the brush being round, about three inches in diameter, with bristles from two to three inches long.

"Hybrex" may be used on the trunks and branches of apple trees for at least one year with safety. It should not be applied to new pruning wounds or buds.

Blocks of apple trees treated with "Hybrex" have exhibited from one-third to two-thirds the number of first brood codling moth injuries occurring in adjacent untreated blocks. Proper application of the recommended cover sprays is essential if this advantage is to be maintained throughout the season.

## INVESTIGATIONS REGARDING BLUE GRASS WEBWORMS IN TURF[1]

By H. F. A. NORTH, *Assistant Research Professor of Agronomy at the Rhode Island Agricultural Experiment Station*, and G. A. THOMPSON, Jr., *Inspector of the Department of Entomology of the Rhode Island State Department of Agriculture.*

ABSTRACT

During 1930–1932 a number of insecticides were tested on webworm infested putting green plats. The species of importance was found to be the Blue Grass Webworm (*Crambus teterellus*). Velvet bent (*Agrostis canina*) was found to be damaged more heavily during 1931 and 1932, than the other species of bent grass and similarly some of the varieties of velvet bent were damaged more heavily than others.

The damage was reduced considerably by the use of arsenate of lead, Paris green or a trade brown patch remedy and soil insecticide; reduced moderately by flooding with dilute pyrethrum extracts and an extract of rotenone; and only reduced slightly by the use of kerosene emulsion. Arsenate of lead 2 pounds in 20 gallons of water per 1,000 square feet of turf is regarded as a very promising remedy.

Rather severe damage to golf turf during late years has been caused by

[1]Published by permission of the Director of the R. I. Agricultural Experiment Station, Kingston, R. I., as Contribution No. 437.

webworms (*Crambus* species). This damage may give a putting green the appearance of a moth-eaten rug and reduce the putting properties proportionately.

Although webworms or close-winged moths have been described by entomologists for over 100 years, but little definite knowledge of the best means for control in fine turf seems to have been published until recently. For this reason a test was begun during 1932 at the Rhode Island Agricultural Experiment Station with certain promising materials in order that the bluegrass webworm (*Crambus teterellus*) in demonstration plats might be held in check. The test has been successful in showing differences in the control properties of eight insecticides.

Ainslie,[2] in 1930, published a comprehensive account of the natural history of the bluegrass webworm (*Crambus teterellus*). Briefly he stated that the webworm may prefer Kentucky bluegrass but will readily feed upon other kinds of grass. The bluegrass webworm was found to be widely distributed over the southern two-thirds of the eastern part of the United States. In dry seasons they may be the real cause for complete killing of sod in pastures and lawns. The larva was found to be the over-wintering stage. There were found to be three broods of moths annually, most abundant during May, July, and September. The moths were described briefly as small, light gray, and with wings folded closely around the body when at rest. They were found to become active about dusk, to be attracted to light in large numbers, to feed only upon water, and after mating to lay approximately 200 to 250 eggs, apparently dropped in flight. Moths are said to live from 7 to 10 days. Eggs hatch into larvae in a similar period and the larvae very rapidly migrate down to the soil level. Here a runway is fashioned from particles of earth or vegetable matter fastened together with silk, in which the worm remains during the day and from which it feeds upon the basal part of the leaves. After from 10 to 14 days in the pupa stage the moths appear. Young succulent growth is preferred and feeding is most active on cloudy days and during the night. No control measures were tried by Ainslie, but it was his opinion that large quantities of moths could be taken with light traps.

A reference to the life history and control of the webworm was published in 1932 by Noble.[3] As regards the natural history it was stated

[2]Ainslie, G. B. The Blue Grass Webworm. U. S. D. A. Tech. Bul. 173, 1930. Abstract published in the Bulletin of the U. S. Golf Assoc., Green Section for June, 1930.

[3]Noble, W. B. Sod Webworms and their Control. Bulletin of the U. S. Golf Assoc., Green Section, 1932. 12 (No. 1): 14–19.

that only some 12 species of webworm are economically important and that their habits are similar. Noble stated also that many of the larvae were eaten by birds. Materials reported by Noble as practically 100 per cent effective were pyrethrum extracts and kerosene emulsion when diluted with water and applied by means of a sprinkling can. The extracts were diluted at 1⅓ to 1⅔ pints to 111 gallons of water per 1000 square feet of turf. The stock solution of the kerosene emulsion was prepared by beating ½ gallon of kerosene into a solution of 1 pound of laundry soap in 1 gallon of boiling water. It was found that an application of 2 1/5 gallons of the stock solution in 111 gallons of water per 1000 square feet of turf was very effective. The pyrethrum extracts, as well as the kerosene emulsion, brought the webworm larvae to the surface in a few minutes where they soon died. Noble reported also that arsenate of lead dusted on at 7½ pounds per 1000 square feet of turf, well brushed and watered in, was found approximately 30 per cent effective. The relative costs of these materials per treatment, as stated, was computed at $4.00 for the pyrethrum extracts, 20 cents for kerosene emulsion, and $1.10 for arsenate of lead. This author mentions that arsenate of lead at 2 pounds in 15 gallons of water used as a spray has been recommended but that this treatment was not tested by him.

WEBWORM DAMAGE TO VELVET BENT VARIETIES, 1930 TO 1932.—In 1930 the demonstration putting-green plats of velvet bent grass at the Rhode Island Agricultural Experiment Station showed a rather general moth-eaten appearance during July and again in September. It was found to be due to webworms. Dusting with four parts of lime to 1 part of arsenate of lead as used on cabbage was not found to be effective.

In 1931 damage occurred again only on the velvet bent varieties and again the moth-eaten appearance was most pronounced in July and September. A poison bait was spread over the plats without result except damage to the turf from the Paris green which it contained. In August an application of a pyrethrum extract was used at approximately 1¼ pints (plus soap) per 40 gallons of water per 1000 square feet. A fair control was obtained and a moderate number of webworms were brought up. Since the damage from the webworms caused the plats to become unsightly again in September, a spray of 4 parts of lime to 1 part of arsenate of lead was applied at approximately ½ pound of the arsenate per 1000 square feet. The latter application was not effective.

Although the materials tried had been mainly ineffective during 1930 and 1931, the facts became increasingly evident that only the velvet bents were noticeably damaged and that some varieties of velvet bent were damaged more than others. Evidence may be had in Table 1 of the

difference in damage between pure velvet bent as compared with colonial velvet bent mixtures. The difference in resistance between the plats of

TABLE 1. PER CENT OF AREA DAMAGED BY BLUEGRASS WEBWORMS AMONG VELVET BENT VARIETIES SHOWING DIFFERENCES IN DAMAGE WHEN MIXED WITH COLONIAL BENT AND WHEN PURE, THE SIMILARITY IN DAMAGE IN 1931 AND 1932, AND THE SEASONAL CHANGE IN 1932

| Varieties of velvet bents in putting green turf | Method and year of planting | Per cent pure velvet bent 1932 | Damage 1931 season | Per cent of area damaged by webworms in 1932 | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | July 30 | Aug. 29 | Sept. 30 | Oct. 30 | Average |
| | 1928 | | | | | | | |
| Kernwood*.... | Stolons | 99.5 | Heavy | 9 | 20 | 9 | 4 | 10.5 |
| Highland..... | Stolons | 99.5 | Heavy | 7 | 2 | 10 | 3 | 5.5 |
| Newport..... | Seed | 60.0 | Medium | 5 | 1 | 1 | 1 | 2.0 |
| German bent.. | Seed | 15.0 | Light | 0.5 | 0.5 | 0.5 | 0 | 0.4 |
| | 1929 | | | | | | | |
| Acme..... | Stolons | 95.0 | Heavy | 10 | 3 | 5 | 3 | 5.2 |
| B.P.I. 14276†. | Stolons | 99.5 | Medium | 3 | 3 | 8 | 2 | 4.0 |
| Mountain Ridge | Stolons | 99.5 | Medium | 2 | 0.5 | 10 | 2 | 3 6 |
| | 1930 | | | | | | | |
| Yorkshire*.... | Stolons | 99.5 | Heavy | 25 | 25 | 35 | 16 | 22.7 |
| Newport..... | Stolons | 98.0 | Heavy | 10 | 2 | 15 | 2 | 7.5 |
| Oregon-grown. | Seed | 5.0 | None | 0 | 0.5 | 1 | 1 | 0.6 |
| | 1931 | | | | | | | |
| Cunningham.. | Stolons | 98.0 | | 0.5 | 0.5 | 25 | 4 | 7.5 |
| Nicholas Ave. No. 2..... | Stolons | 98.0 | | 0.5 | 0.5 | 15 | 0.5 | 4.1 |
| Highland..... | Seed | 99.5 | | 3 | 0.5 | 10 | 2 | 3.9 |
| Highland..... | Stolons | 99.5 | | 1 | 2 | 10 | 2 | 3.7 |
| Kernwood..... | Seed | 99.5 | | 4 | 2 | 5 | 2 | 3.2 |
| B.P.I. 14276... | Seed | 99.5 | | 3 | 1 | 7 | 1 | 3.0 |
| Nichols Ave. No. 1..... | Stolons | 99.0 | | 0.5 | 0.5 | 10 | 0.5 | 2.9 |
| Wykagyl..... | Stolons | 99.0 | | 0.5 | 0.5 | 10 | 0.5 | 2.9 |
| Prince Edward Island..... | Seed | 20.0 | | 0 | 0.5 | 1 | 1 | 0.6 |
| Valentine No. 2 | Stolons | 99.0 | | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Elizabeth..... | Stolons | 90.0 | | 0.5 | 0 | 0.5 | 0.5 | 0.4 |
| B.P.I. 14276... | Stolons | 97.0 | | 0 | 0 | 0.5 | 0.5 | 0.2 |
| | 1932 | | | | | | | |
| Yorkshire..... | Seed | 99.5 | | 0.5 | 2 | 4 | 3 | 2.4 |
| Average of all varieties..... | | | | 4.8 | 4.1 | 9.4 | 2.7 | |
| Average of all but Kernwood* and Yorkshire* varieties..... | | | | 2.3 | 1.1 | 6.5 | 1.4 | |

*Used for the main test, 1932.
†Used for the later test, 1932.

pure velvet bent in 1931 and 1932 are shown as well as the monthly change in severity during 1932 from July to October.

It may be seen from Table 1 that varieties such as Kernwood and Highland planted in 1928, Acme of 1929, and Yorkshire of 1930 were more heavily damaged both during the seasons of 1931 and 1932, than

other varieties planted the same year. The varieties B. P. I. 14276 and Mountain Ridge were similarly less heavily damaged during both seasons. These are relatively pure velvet bents. When the varieties which are somewhat mixed with colonial bent such as Newport and German bent of 1928, Oregon-grown seed of 1930, or Prince Edward Island of 1931 are compared with pure velvet bent they are found to have been less damaged in both seasons than the relatively pure turf. The same point is brought out by a comparison of Newport (seed) of 1928 and Newport (stolons) of 1930. It will be noticed that the varieties planted in 1931 were as a rule less damaged during 1932 than those planted during the years previously. The average percentage of damage for all varieties except Kernwood of 1928 and Yorkshire of 1930 indicates rather clearly that the infestation of webworms was the greatest in July and September and that the September attack was the most damaging. Two of the varieties which were seriously damaged in 1931 were selected for use in the test of the insecticides mentioned previously. These were the velvet bents, Yorkshire of 1930 and Kernwood of 1928.

The Yorkshire variety originated in the county of the same name in England. It is an extremely fine, vivid light green and upright variety but seems poorly adapted to warm weather. The brown patch preventative treatment used during the past two years has benefited the Yorkshire much more than the Kernwood variety. Kernwood velvet bent originated from a plant found growing on the Kernwood Country Club, Salem, Massachusetts. It has a bright, medium green color, upright habit, and above average fineness of leaf. The Kernwood variety is well adapted to the climate of this region and for that reason is probably the better grass for a test of insecticides. Both varieties have been mildly attacked by large and small brown patch.

Method of Test, 1932.—Both varieties are planted in 20 foot plats, allowing each to be divided into sixteen 5-foot by 5-foot subplats. Since the damage from webworms was rather evident before the treatments were applied, an estimate was made of this damage for each subplat. The 32 subplats available permitted four subplats each for the seven treatments and for four subplats left untreated. In other words each of the seven materials was tested four times, twice on Yorkshire and twice on Kernwood. All of the materials were applied August 6th and October 10th. On October 10, arsenate of lead, 4 pounds per 1000 square feet, was substituted for Paris green because the latter was found to kill out patches of the Yorkshire turf. The per cent of area damaged by webworms in each subplat was estimated again on August 30, September 30, and October 28.

Methods of application, rate of application, source, and cost of the materials for treating 1000 square feet of turf are as follows:

1. Arsenate of lead. This was used as a spray at two rates: (1) ½ pound, and (2) 2 pounds in 20 gallons of water. The cost is approximately 7 cents and 30 cents, respectively, for material per treatment.

2. Paris green. A spray was made with ½ pound of the powder in 20 gallons of water. As mentioned previously this was found to injure the turf. The cost is approximately 30 cents for materials per treatment.

3. Trade material A is a trade-marked remedy for brown patch and soil insects. It was sprayed on at ⅓ pound in 20 gallons of water and the cost is approximately 67 cents for materials per treatment.

4. Pyrethrum No. 1 and Pyrethrum No. 2 are trade products usually available locally. In this test each was diluted at the rate of 1½ pints per 111 gallons of water and applied with a sprinkling can. Dissolved soap was used with the Pyrethrum No. 2. The cost of materials of each is approximately $4.00 per treatment.

5. Kerosene emulsion. The stock solution consisted of 1 pound of laundry soap, 1 gallon of boiling water, and ½ gallon of kerosene. The kerosene was gradually beaten into the hot soap solution. This stock solution was diluted at the rate of 2 1/5 gallons per 111 gallons of water and applied with a sprinkling can. The cost of materials is approximately 20 cents per treatment.

Results.—In Table 2 are given the treatments which were applied on August 6 and October 10, the estimate of damage on August 6 before the materials were applied, and the average of the estimates of August 30 and October 28. The estimate of September 30 was found to be of little value since nearly two months had elapsed since the treatment on August 6. It will be seen from Table 2 that the damage on August 6 was not uniform among the subplats devoted to the various treatments. For this reason the average of the estimates of August 30 and October 28 was divided by the estimate of August 6 to obtain the corrected average estimate. This was obtained both for brown patch treated and untreated subplats. In the next column corrected averages for the treated and untreated subplats are averaged. The same tabulations are given for each variety of grass. At the extreme right is given the corrected average damage of the four subplats of the same treatment.

Considering the data in Table 2 for the Yorkshire variety it may be seen that approximately twice the damage occurred on the subplats which were not treated for brown patch as compared with the subplats which were given this mercury treatment. The ⅓ bichloride, ⅔ calomel treatment was used as recommended by the U. S. Golf Association.

It may be seen that the corrected average damage on both the treated and untreated was the least when sprayed with arsenate of lead (2 pounds) or material A, and greatest when no treatment was given. It is also evident that the better treatments on the Yorkshire are also the better ones on the Kernwood variety.

TABLE 2. THE RESULTS OBTAINED WITH VARIOUS TREATMENTS FOR CONTROL OF BLUEGRASS WEBWORMS IN VELVET BENT PUTTING GREEN TURF. THE AVERAGE OF THE PERCENTAGE DAMAGE OF AUGUST 30 AND OCTOBER 28 WAS DIVIDED BY THE PER CENT DAMAGE OF AUGUST 6 BEFORE TREATMENTS WERE APPLIED IN ORDER TO OBTAIN THE CORRECTED AVERAGE DAMAGE

| Treatment | Estimates of damage before and after treatment Plat 17—Yorkshire (1930) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aug. 6 | | Average Aug. 30 and Oct. 28 | | Corrected Aug. 30 and Oct. 28 | | aver. T and Unt. | Corrected average for all subplats |
| | T | Unt. | T | Unt. | T | Unt. | | |
| Arsenate of lead, 2 lbs. | 20 | 20 | 6 | 16.5 | 30 | 55 | 42 | 24 |
| Paris green | 25 | 30 | 6.5 | 24 | 26 | 80 | 53 | 35 |
| Trade Material A | 15 | 30 | 5 | 19.5 | 33 | 65 | 44 | 37 |
| Pyrethrum No. 1 | 20 | 25 | 4.7 | 21.5 | 24 | 86 | 52 | 43 |
| Pyrethrum No. 2 | 15 | 30 | 7.5 | 31.5 | 50 | 105 | 72 | 57 |
| Arsenate of lead, ½ lbs. | | 30 | | 27.5 | | 92 | 79 | 74 |
| No treatment | 20 | | 15 | | 75 | | 82 | 86 |
| | 20 | | 18 | | 90 | | | |
| Kerosene emulsion | 20 | 30 | 10.5 | 31.5 | 52 | 105 | 79 | 103 |
| Average | | | | | 48 | 82 | | |
| | Kernwood (1928) | | | | | | | |
| Arsenate of lead, 2 lbs. | 10 | 10 | .5 | .5 | 5 | 5 | 5 | 24 |
| Paris green | 10 | 15 | 2.2 | 1.7 | 22 | 12 | 17 | 35 |
| Trade Material A | 10 | 10 | 5 | 1 | 50 | 10 | 30 | 37 |
| PyrethrumNo. 1 | 10 | 5 | 5.2 | .7 | 52 | 15 | 33 | 43 |
| Pyrethrum No. 2 | 12 | 12 | 8.5 | 1.7 | 71 | 13 | 42 | 57 |
| Arsenate of lead, ½ lbs. | 7 | 10 | 8.7 | 1.2 | 125 | 12 | 69 | 74 |
| No treatment | 7 | 10 | 3 | 13.5 | 43 | 135 | 89 | 86 |
| Kerosene emulsion | 10 | 10 | 10 | 15.2 | 100 | 152 | 126 | 103 |
| Average | | | | | 58 | 58 | | |

T = Brown patch treatment.
Unt. = No brown patch treatment.

The most satisfactory indication in the table is the similarity between the rank of the materials obtained as the average of all the subplats and the rank on the Kernwood variety. Arsenate of lead applied at the rate of 2 pounds per 1000 square feet has given considerably the best control on the Kernwood and was the best in the averages of each of the varieties. Material A and pyrethrum No. 1 were found to be about equally effective on the Kernwood and when all plats were averaged. Pyrethrum No. 2 seemed to give somewhat less control than pyrethrum No. 1. Only a very slight effect on the webworms resulted from the use of arsenate of lead, ½ pound. The kerosene emulsion was least effective of all treatments.

PRELIMINARY TEST OF ANOTHER TRADE PRODUCT.—Another test was begun on October 10 as indicated in Table 3. This was placed on the plat of B. P. I. 14276 velvet bent planted in 1929. This plat lies between the Yorkshire and Kernwood plats which were used in the test described above. There were 16 subplats and 3 treatments, rotenone, pyrethrum No. 1, and arsenate of lead, 2 pounds. The former is a trade extract of rotenone which is both a stomach and contact poison. A note was taken on October 28 of the per cent of area damaged and the last column of the table (3) gives the average damage for the four subplats.

The test merely indicates that some control was obtained with all materials tried and that arsenate of lead may be fully as effective as either rotenone or pyrethrum No. 1 as applied in this test.

TABLE 3. RESULTS OF A TEST OF MATERIALS APPLIED ON OCTOBER 10 FOR CONTROL OF BLUEGRASS WEBWORMS. THE TABLE GIVES THE NUMBERS OF THE SUBPLATS WHICH RECEIVED PARTICULAR TREATMENTS, THE RATE OF APPLICATION OF THE INSECTICIDES, THE PERCENTAGE DAMAGE ON OCTOBER 28 AND THE AVERAGE OF THE DAMAGE ON THE FOUR SUBPLATS

| Subplats | Treatments | Per cent damage Oct. 28 | Average |
|---|---|---|---|
| 1–7–9–15 | Check—no treatment | 0–0–1–8 | 2.25 |
| 2–8–10–16 | Rotenone—1¼ pints per 111 gals. water per 1000 square feet. Cost—approximately the same as pyrethrums | 0–0–0–1 | .25 |
| 3–5–11–13 | Pyrethrum No. 1—same as for rotenone | 0–0–2–0 | .50 |
| 4–6–12–14 | Arsenate of lead—2 lbs. in 20 gals. water per 1000 square feet | 0–0–0–0 | .00 |

The results of both experiments indicate that arsenate of lead, (2 pounds) was the most effective treatment for webworms under the conditions which prevailed during the past season. Since arsenate of lead is commonly used in the control of grubs, earthworms, and mouse-ear chickweed it could be applied as a spray for the control of webworms with little additional expense. Paris green was effective on the webworms but injured the turf severely. A rather high rank among the insecticides was won by material A. A moderate control was obtained with pyrethrum No. 1 and somewhat less with pyrethrum No. 2. Arsenate of lead (½ pound) was only slightly effective.

SUMMARY.—Damage from the bluegrass webworm in demonstration plats of velvet bent during 1930 and 1931 was rather serious. A test was begun in August, 1932, of various promising insecticides. Two doses were applied on two varieties of velvet bent. The results indicate the following ranking as to effectiveness at the rates given per 1000 square feet:

1. Arsenate of lead, 2 pounds in 20 gallons of water sprayed into the turf. Pressure was maintained at approximately 50 pounds.

2. Paris green, ½ pound diluted and applied as No. 1.

3. Material A,—brown patch and soil insecticides—⅓ pound in 20 gallons water as a spray.

4. Pyrethrum No. 1,—pyrethrum extract applied with a sprinkling can at the rate of 1½ pints in 111 gallons of water.

5. Pyrethrum No. 2,—pyrethrum spray applied with a sprinkling can at the same rate as No. 4.

6. Arsenate of lead at ½ pound in 20 gallons of water as a spray.

7. No treatment or check plats.

8. Kerosene emulsion applied at the rate of 2 1/5 gallons of stock solution in 111 gallons of water and applied with a sprinkling can.

A similar test was begun on October 10 of rotenone, pyrethrum No. 1, and arsenate of lead (2 pounds) for webworm control. In this test arsenate of lead (2 pounds) was fully as effective as the other treatments.

## IRREGULARITY AMONG COTTON PLANTS IN TIME OF FRUITING AS A FACTOR AFFECTING SUSCEPTIBILITY TO DAMAGE BY THE COTTON BOLL WEEVIL

By P. W. CALHOUN, *Gainesville, Fla.*

ABSTRACT

Considerable irregularity seems to exist among cotton plants as regards earliness of fruiting. Using the time of appearance of the first blossom on each plant as the criterion, the frequency distribution for 600 plants approximated a normal curve, the maximum for the frequency histogram occurring on the 11th day. It is suggested that such lack of uniformity in time of fruiting perhaps contributes to increased susceptibility of cotton to damage by the boll weevil (*Anthonomus grandis* Boh.).

The peculiar shape of some rate-of-blossoming curves, in which the number of blossoms per day was determined by mass counts, suggested to the writer that perhaps considerable irregularity might exist among cotton plants as to the time each plant begins to fruit. One such curve suggested rather strongly that a small percentage of the plants were much earlier bloomers than the majority of the plants of that group. These few early plants apparently—judging solely from the shape of the blossom curve—also ceased to blossom earlier than the majority of the plants. In other words, in this case at least, considerable lack of coordination seemed to exist among the different plants as to the time each produced its crop.

Such a condition would obviously contribute to greater susceptibility to damage by the boll weevil, for the few early plants would serve as

early breeding places for weevils which would migrate to the later plants before the bolls on the latter had matured. Under some conditions it would appear possible for a few very early plants to do considerable damage in this manner.

In view of the above, it seemed desirable to determine approximately the degree of irregularity which exists in the time of fruiting of the different cotton plants. Six blocks of 100 plants each of upland cotton were staked off, and the date on which each plant produced its first

TABLE 1. AVERAGE PER CENT OF PLANTS WHICH BEGAN BLOOMING ON SIX BLOCKS OF 100 PLANTS EACH OF UPLAND COTTON AT GAINESVILLE, FLA., 1930

| Number of count | Average per cent beginning to blossom on count indicated* | | Number of count | Average per cent beginning to blossom on count indicated* | |
|---|---|---|---|---|---|
| | Daily | Total | | Daily | Total |
| 1 | 1.5 | 1.5 | 14 | 1.8 | 56.9 |
| 2 | 1.7 | 3.2 | 15 | 5.7 | 62.6 |
| 3 | 2.0 | 5.2 | 16 | 5.7 | 68.3 |
| 4 | 3.7 | 8.9 | 17 | 6.7 | 75.0 |
| 5 | 2.8 | 11.7 | 18 | 3.8 | 78.8 |
| 6 | 4.5 | 16.2 | 19 | 2.3 | 81.1 |
| 7 | 4.3 | 20.5 | 20 | 2.2 | 83.3 |
| 8 | 4.7 | 25.2 | 21 | 1.8 | 85.1 |
| 9 | 5.5 | 30.7 | 22 | 2.7 | 87.8 |
| 10 | 6.3 | 37.0 | 23 | 2.0 | 89.8 |
| 11 | 7.8 | 44.8 | 24 | 2.5 | 92.3 |
| 12 | 7.3 | 52.1 | 25 | 1.0 | 93.3 |
| 13 | 3.0 | 55.1 | 26 | 1.3 | 94.6 |

Weighted average for 26 counts, 12.6.

*The percentages given in this column represent one-sixth of the sum of the percentages which blossomed on each block on the corresponding count. The recorded counts for each block were begun upon the appearance of the first blossom on that block.

blossom was recorded. From these data the rate-of-beginning-to-blossom was calculated for each block of 100 plants—the rate being calculated as the percentage of plants which produced their first blossom on each count. The recorded counts were begun on each block on the day the first blossom appeared on that block.

The rates-of-beginning-to-blossom for the six blocks were then averaged by adding the percentage of plants which had produced their first blossom on each count and dividing by six. Table 1 and Fig. 103 show these data in tabular and graphic form respectively.

It is apparent from Table 1 and figure 103 that considerable irregularity in earliness of fruiting did exist among the plants. The very earliest plants blossomed about 12 days earlier than the last half. While it is true that the first half of the plants to blossom would, in the entire absence of boll weevils, produce more cotton than the last half to blossom, nevertheless a large part of the plants which did produce an average

number of bolls began to fruit nine or ten days later than the earliest ten per cent. Had a heavy infestation of boll weevils been in the field, it seems plausible that the presence of the very early plants would have reduced the crop rather than increased it, by increasing the weevil damage on the much more numerous plants of only average earliness.

Comparison of the frequency histogram with the normal curve of best fit shows that the variation in earliness of beginning to fruit approximated a normal distribution.

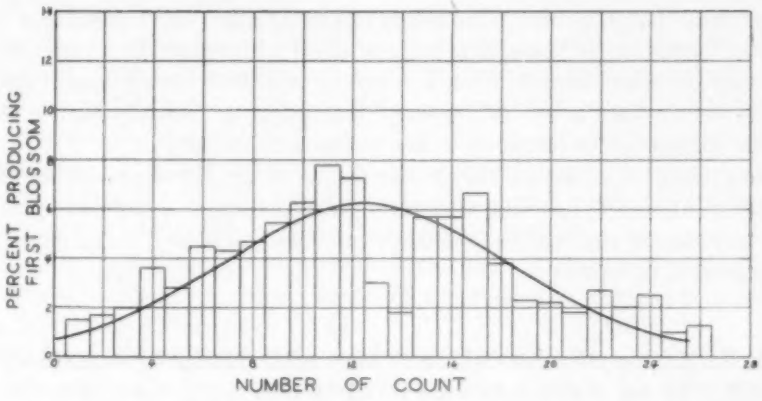


FIG. 103.—Frequency histogram based on data of Table 1, with normal distribution curve of best fit.

No especial effort was made to select conditions which would tend to reduce to a minimum the irregularity in time of fruiting. The spacing in some of the blocks was wider than in others. Most of them, however, were spaced from 8 to 12 inches in the drill, with from one to two plants per hill. The variety used, in all but one block, was a strain of Lightning Express which has been a consistent high yielder at Gainesville. All blocks were fertilized with 400 lbs. of 8-4-4 at planting time and all received an application of soda at chopping time.

A poor stand was secured in two blocks, and these had the skips filled in by later plantings with a hoe. These two blocks showed some, but not a great deal, more variation in time of beginning to blossom among the different plants than the other blocks. One block was planted considerably later than the others. There was less variation in time of beginning to blossom in this block than in the others. However, none of the blocks varied greatly from the mean of the group, and most of them were very close to the mean. Conditions were such that the writer

would expect the variations observed to be very comparable to those which would be found under high-grade general farming practice.

In the procedure used for making Table 1 it should be noted that the starting date for each block is considered the same, in spite of the fact that actually some of the blocks began to blossom a week or more earlier than the others, due to differences in soil types, spacing, etc. In a sense this reduces somewhat the apparent irregularity among the plants in time of beginning to blossom for the group of six hundred plants, since, according to the procedure used, each plant is compared only with the plants near it. However, this seems desirable when the irregularity in time of beginning to blossom is being studied with regard to its effect on the susceptibility of cotton to damage by the boll weevil, since most of the weevils that breed on the early plants during the early part of the season migrate only to plants in the immediate vicinity.

No attempt was made to study the causes of the variation among the plants in time of beginning to fruit. Environmental conditions probably are largely responsible, although very likely it is to a certain extent a varietal characteristic.

## THE NUMBER OF LARVAL INSTARS AND THE APPROXIMATE LENGTH OF THE LARVAL STADIA OF *DENDROCTONUS PSEUDOTSUGAE* HOPK., WITH A METHOD FOR THEIR DETERMINATION IN RELATION TO OTHER BARK BEETLES

By W. D. BEDARD, *Assistant Entomologist, United States Bureau of Entomology, Forest Insect Field Station, Coeur d'Alene, Idaho*

ABSTRACT

Investigators encounter considerable difficulty in studying the development and habits of larvae which mine beneath the bark of trees. A method is here outlined whereby such a study can be accomplished, and its application is demonstrated in the case of the Douglas-fir beetle (*Dendroctonus pseudotsugae* Hopk.). The usefulness of this information in a thorough study of larval parasites and its value in the economic control of the Douglas-fir beetle are shown.

Past investigative studies of bark beetles have given but scant attention to larval development, because the economic value of such detailed information was not then apparent. Control measures were developed and put into practice with little or no consideration for the biological control factors involved. As a result, most of the controls now in use, though successful in destroying the pest, are perhaps equally destructive to the beneficial parasitic and predacious insects as well.

With a greater realization of the economic value of these biological agents, studies have been instituted with the object of timing present methods of control so that full advantage can be taken of the natural enemies of the pest. The purpose of this paper is to show how a more thorough knowledge of larval development may contribute towards a solution of our problems of bark-beetle control, and to outline a method which was found to be of considerable aid in studying the larval habits of the Douglas-fir beetle.

Following the entrance of bark beetles into the new hosts, there is a well defined lapse of time before the resulting broods are attacked by parasites and some of the predators. If it were possible to direct control measures against the bark beetles only during this period, the beneficial insects would be saved, and thus the control would be far more effective. In determining the length of time available for the application of such favorable control before the appearance of any particular parasite for which protection is desired, it is necessary to ascertain which larval instar of the host is preferred by the parasite, and when this stage of development is reached by the bark-beetle larvae. To accomplish this, it is obviously necessary to have a thorough knowledge of the larval development of the host larvae.

Furthermore, a knowledge of larval habits is required for the successful colonization of a parasite in a new locality, because the adult parasites must be liberated at a time when the host is in the proper stage to be parasitized; i. e., when the preferred instar is available in suitable numbers.

Finally, a knowledge of larval development might contribute in a number of ways to the scanty information now available regarding bark-beetle fluctuations. For example, it might be found that one instar consistently showed a high mortality rate and that conditions preceding an epidemic had been optimum for the bark beetle during the duration of this instar, with the result that a large percentage of the brood had lived through this critical period. In such a case the increase would be sufficient to disturb seriously the natural balance and result in a rapid building up in the numbers of the pest. In addition, such a study might demonstrate a lack of synchronization between the seasonal histories of parasite and host which would cause a decrease in the abundance of the parasite with a subsequent increase in the numbers of the beetle.

The importance of possessing these data became apparent in a study of the braconid *Coeloides brunneri* Vier., which is the most important larval parasite of the Douglas-fir beetle. The study was carried on in connection with an investigation of this beetle.

These Dendroctonus larvae mine in the phloem of the host tree, and consequently extreme difficulty arises in making daily observations for the purpose of counting the number of molts and recording the time which elapses between the consecutive ecdyses. Several rearing devices

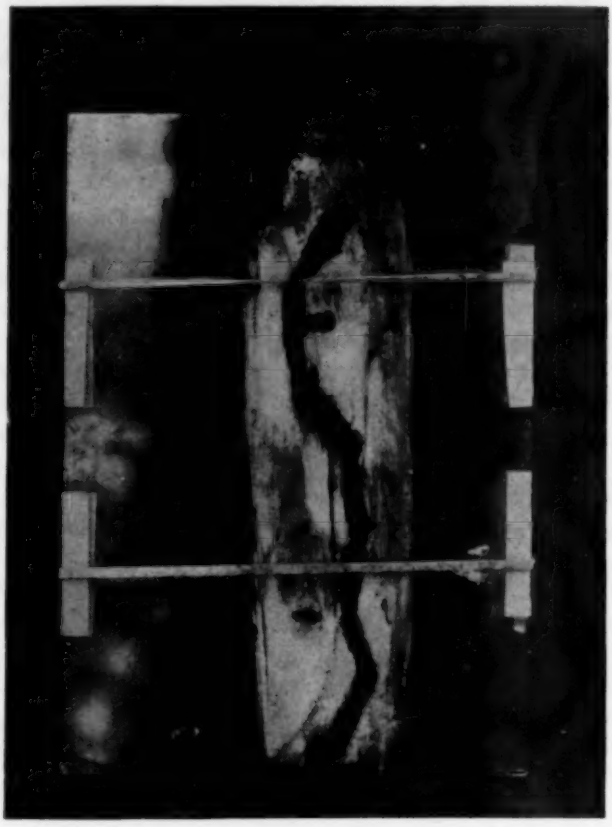

FIG. 104.—One of the glass-plate rearing devices used in this study. (Photograph by H. J. Rust.)

were tested to accomplish this purpose, but, with one exception, they were not successful. Fair results were obtained by allowing adult female beetles to construct galleries in a thin sheet of inner bark, held between two plates of ordinary window glass. (Fig. 104.) The bark was pared to such thinness that the beetles were allowed just sufficient room to work between the two glass plates yet were kept visible at all times. Although not shown in the illustration, it was found necessary to pack cotton

around the bark between the two plates and moisten the cotton daily in order to prevent excessive drying of the bark. The entire device was then wrapped in a black cloth to exclude light and thus make conditions more natural for the insect. Successful incubation of eggs was obtained in this apparatus, and the resultant larvae could be observed daily in the tunnels until, during the second stadium, they passed out of sight into the host material. By transferring the larvae to a thinner piece of material it was hoped to prevent this disappearance, but the needed reduction in thickness caused rapid drying of the bark with subsequent larval mortality.

Unfortunately, there is no anatomical character whereby the various instars can be distinguished from one another and, as the size of the body

TABLE 1. COMPARISON OF THEORETICAL AND ACTUAL DIMENSIONS OF HEAD CAPSULES OF LARVAE OF THE DOUGLAS FIR BEETLE

| Dimension | Instar | Theoretical measurement | Actual measurements: Mean | Standard deviation | Min. | Max. | Individuals measured |
|---|---|---|---|---|---|---|---|
| | | *Mm* | *Mm* | *Mm* | *Mm* | *Mm* | *Number* |
| Length | 1 | *0.454 | 0.462 | 0.031 | 0.428 | 0.523 | 200 |
| | 2 | * .583 | .552 | .0197 | .500 | .600 | 200 |
| | 3 | .746 | .734 | .0327 | .650 | .800 | 200 |
| | 4 | .955 | .919 | .0547 | .785 | 1.025 | 200 |
| | 5 | *1.21 | 1.24 | .0788 | 1.125 | 1.375 | 200 |
| Width | 1 | * .507 | .523 | .024 | .476 | .585 | 200 |
| | 2 | * .644 | .615 | .0126 | .585 | .685 | 200 |
| | 3 | .824 | .791 | .0478 | .700 | .850 | 200 |
| | 4 | 1.05 | 1.03 | .0803 | .900 | 1.20 | 200 |
| | 5 | *1.34 | 1.38 | .0766 | 1.238 | 1.50 | 200 |
| Width of frons | 1 | * .270 | .278 | .0475 | .230 | .385 | 200 |
| | 2 | * .347 | .365 | .0217 | .350 | .400 | 200 |
| | 3 | .444 | .482 | .030 | .400 | .550 | 200 |
| | 4 | .568 | .618 | .0479 | .500 | .700 | 200 |
| | 5 | * .727 | .811 | .0455 | .666 | .900 | 200 |

*Mean of actual measurements of 50 head capsules.

is so variable, the head-capsule dimensions are the only criteria for identification. It was possible, however, by this type of rearing, to secure head capsules from two successive ecdyses, namely, those of the first and second instars. With measurements made of these, and the aid of Dyar's Law,[1] which is applicable also to these beetles, a series of figures can be calculated which represent the head-capsule dimensions for any number of ecdyses which may follow the two already known. In order to terminate this series properly, head capsules from last larval

[1]Dyar, H. G. 1890. The number of molts of lepidopterous larvae. Psyche 5: 420–422.

instars can be collected from pupal cells and measured to determine which of the calculated figures is that of the last instar.

In the case of *Dendroctonus pseudotsugae*, 50 head capsules each of the first, second, and last instars were secured and measured. In addition

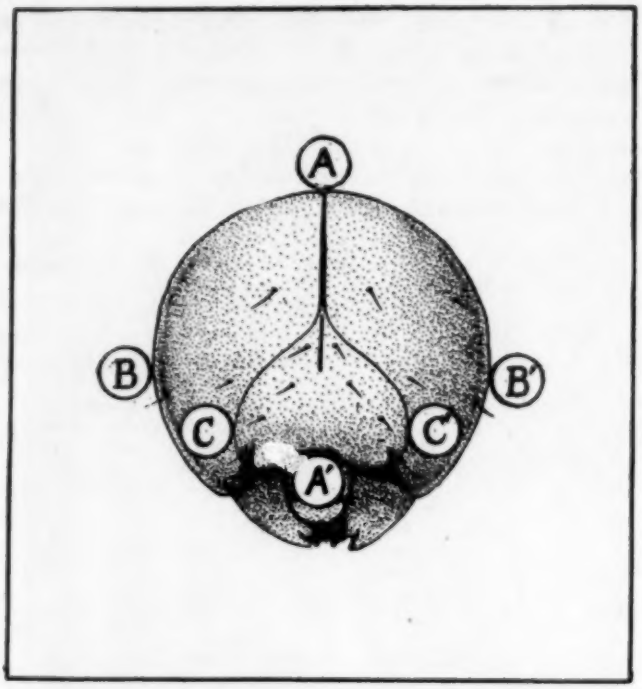


FIG. 105.—Head capsule of *D. pseudotsugae* larva, showing measurements taken. A-A¹ length. B-B¹ width. C-C¹ width of frons.

to the usual measurements of length and width, a third measurement, the width of the frons, was taken. (Fig. 105.) This additional dimension was used because the head capsules found attached or adjacent to the Coeloides hibernacula are usually broken, and very often the width of the frons is the only measurement obtainable. Table 1 gives a comparison of the head-capsule dimensions, as obtained by the above method, with the average dimensions secured by actual measurement of 200 entire head capsules from each instar.

Table 1 shows that the theoretical dimensions for the first, second, and last instars check very closely with those obtained by the actual measurement of a large number of additional head-capsules and that

the material is well centered within the range. Because these dimensions checked so closely and because all head-capsules not of the first, second, or fifth instars fell definitely into two groups, the author felt justified in calling these the third and fourth instars and checking them against the theoretical dimensions. It will be noted that there is some overlapping between the sizes of the head-capsules of the various instars. However, when a doubtful case occurs with one measurement, it has been found that one or both of the other two measurements will show to what instar the head-capsule belongs.

Having thus established the number of instars of the host larva, it was desired to determine the approximate duration of each stadium. Taylor[2] describes a method for so doing when the larvae to be studied are hidden in the host material, as are the cambium miners and leaf miners. Briefly, this is done by collecting a number of the larvae each day and recording the instars collected under the date of collection. Then the length of each stadium can be calculated by counting the number of days from the first appearance of one instar to the first appearance of the next instar and the number of days between the last dates of appearance of the same two instars, adding these two numbers together, and dividing their sum by 2.

TABLE 2. RANGE OF OCCURRENCE OF THE VARIOUS INSTARS OF THE DOUGLAS-FIR BEETLE AND THE CALCULATED LENGTH OF THE STADIA

| Instar | First occurrence | Interval till first occurrence of next stadium *Days* | Last occurrence | Interval till last finding of next stadium *Days* | Average duration of stadium *Days* |
|---|---|---|---|---|---|
| Instar 1 | June 9 | 6 | July 15 | 6 | 6 |
| Instar 2 | June 15 | 15 | July 21 | 11 | 13 |
| Instar 3 | June 30 | 14 | Aug. 1 | 18 | 16 |
| Instar 4 | July 14 | 13 | Aug. 19 | 19 | 16 |
| Instar 5 | July 27 | 18 | Sept. 7 | 16 | 17 |
| Pupa | Aug. 14 | — | Sept. 23 | — | — |

In the application of this method, approximately 50 Douglas-fir beetle larvae were collected daily from a regular route which comprised 10 trees, 2 of which were windfalls. These trees represented varying conditions of bark thickness and exposure to the sun, and at each collection larvae were taken from all four sides of the tree. This diversified material was selected because of the effect which temperature and humidity exert upon the development of bark-beetle larvae. Table 2 shows the incidence of the various instars as found by these collections

[2]Taylor, R. L. 1930. A simple statistical method for determining the approximate duration of the instars of leaf-mining larvae and others. Journal of Economic Entomology 23: 587–595.

and the application of Taylor's method for the determination of the lengths of the various stadia.

Thus the approximate durations of the various stadia, from the first instar to the fifth, are 6, 13, 16, 16, and 17 days, respectively. These stadium lengths, although only approximate, are nevertheless quite applicable for the purposes already pointed out. For example, head-capsules of parasitized Douglas-fir beetle larvae are found clinging to the Coeloides hibernacula. Two hundred of these capsules were collected and measured, and it was found that only the fourth instar and a few fifth-instar larvae had been parasitized. By consulting Table 2, it can be seen that fourth-instar larvae do not appear until about the middle of July. Attacks by this beetle begin early in May and the parasite emerges approximately two months later in order that the preferred larval instar of the host will be present in the newly attacked trees when oviposition begins. The control methods used at present comprise the decking and burning of the infested logs in the fall of the year, thus destroying the parasite as well as the beetle. However, control operations using the decking and burning method can be instituted about the first of June and continued until the middle of July without any destruction of the parasite. It is not definitely recommended, however, that control be done in the spring in preference to the fall, because in some areas the method would prove to be a great fire risk which would prohibit its use; although the work could be done successfully in other areas. Furthermore, it is not known whether the advantage secured in preserving the parasite will compensate for the numerical increase of the bark beetle if fall control is omitted and the beetles are allowed to perpetrate the spring attack before control is undertaken. These problems must be solved before the actual recommendation of spring control, but analyses of data indicate that the change may prove to be a feasible one.

In conclusion, it might not be amiss to remark that the duration of the various stadia, as given in this paper, can not be taken as standard throughout the range of the insect. Climatic factors exert such a strong influence upon insect development that, of necessity, the investigation must be conducted in the locality where the data obtained from the study are to be applied.

# THE RESISTANCE OF LEAVES OF RED CLOVER TO PUNCTURING[1]

By H. H. JEWETT, *Kentucky Agricultural Experiment Station.*

ABSTRACT

Leaves of a Kentucky red clover, No. 101, and an Italian red clover were tested as to resistance to needle puncturing. It was found from puncturing 500 leaves of each clover that the Kentucky clover offered greater resistance to puncturing than the Italian clover. The Kentucky clover is more resistant to leafhopper injury than the Italian clover. Since the insect feeds by puncturing plant tissue, it is thought that this greater resistance to leafhopper injury is due, in part at least, to greater resistance to puncturing.

A study of injury to red clover by the leafhopper, *Empoasca fabae*, has shown that while clovers with rough hairy pubescence are injured less than those with appressed pubescence or without pubescence, not all hairy strains are equally resistant. Clovers with practically the same number of hairs differed considerably as to their ability to resist hopper injury. This was shown by a series of tests made in 1932.[2]

Since this insect gets its food by piercing the tissues with its beak, it was thought that some kinds of clover may be more easily punctured than others. In order to measure resistance to puncturing, an instrument with a very fine needle was made for the purpose. A Kentucky and an Italian red clover were selected for the tests and 500 leaves of each kind were punctured.

METHOD OF PROCEDURE.—The clovers used in the tests were grown in pots in the greenhouse. They were the same age and were grown under the same conditions of moisture, lighting and temperature. The plants were small and were graded as nearly as possible as to size and condition of growth.

All leaves of the plants selected for the tests were punctured. The punctures were made in the central portion of each leaf and several trials were generally required before a satisfactory reading could be taken. The weight necessary to force the needle through the leaf varied for different leaves on the same plant and for different plants.

The apparatus used for puncturing the leaves is illustrated in Fig. 106. The bar at the right side of the pivot is marked with a millimeter scale. The pressure which the bob (A) exerts upon the needle was determined

[1]The investigation reported in this paper is in connection with a project of the Kentucky Agricultural Experiment Station and is published by permission of the Director.

[2]Kentucky Agricultural Experiment Station, Bulletin 329. The Resistance of Certain Red Clovers and Alfalfas to Leafhopper Injury.

for each scale division, and tabulated. The table or rest (B) for supporting the object has a small opening for the passage of the needle. This table was kept at the same elevation while the readings were being taken. The lever (C) could raise or lower the needle.

To operate the instrument, a leaf is placed on the object-table, the needle is lowered till contact with the leaf is made and the weight bob is shifted to a position where the needle punctures the leaf. A glance at the table shows the correct weight necessary to make the puncture.

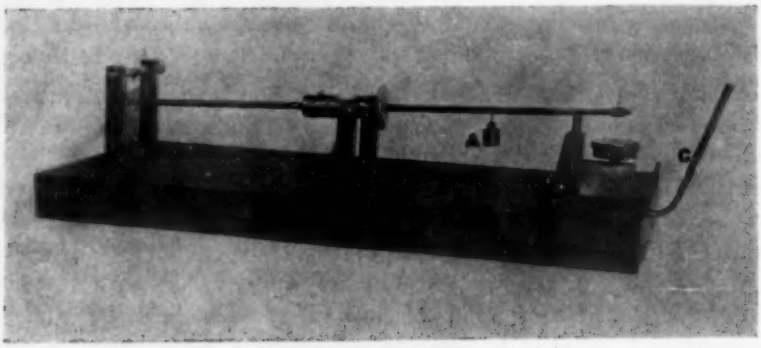


FIG. 106.—Apparatus for puncturing the clover leaves.

RESULTS OF THE TESTS.—The weights, in grams, necessary to force the needle through the leaves of the clovers all come within the range of 1.50 to 3.79. The weights for each clover were arranged in a table and the mean, and standard deviation were determined for each. The standard error of the difference of the two means was then determined. The mean for the Kentucky clover was 2.777 grams, with a standard deviation .3943. The mean for the Italian clover was 2.662 grams with a standard deviation .3845. The actual difference between the two means was .115 grams. The standard error of the difference of the two means was .0246.

The difference between the two means is over 4.6 times the standard error of the difference of the two means. It is customary to take a difference of three times the standard error as indication of complete reliability, since—$3\sigma$ includes practically all of the cases in the "distribution of differences" below the mean. Under the Normal Probability Curve (P 91, Table 10, Statistics in Psychology and Education by Garrett) we find that 9999.932 cases in 10,000 or 99.999 per cent of the distribution fall within the limits set by $-4.5\sigma$ and $+4.5\sigma$ (by cutting off the curve at these two points only .001 of 1 per cent is disregarded).

It is clear that the chances are 9999.932 in 10,000 that the true differences between the averages of the Kentucky weights and the Italian weights is greater than zero. We may be certain, therefore, that there is a true difference between the average weights in favor of the Kentucky clover and that the average Kentucky red clover leaf is more difficult to puncture than the average Italian red clover leaf.

Since leaves of the Kentucky clover offer greater resistance to needle-puncturing than leaves of the Italian clover, it is reasonable to assume that they offer greater resistance to puncturing by the leafhopper.

## FRUIT INJURY ON APPLES FOLLOWING NICOTINE TANNATE SPRAYS*

By BYRLEY F. DRIGGERS, *Associate Entomologist, New Jersey Agricultural Experiment Station.*

ABSTRACT

A peculiar type of fruit injury following the use of nicotine tannate on apples was not duplicated when three varieties of apples were sprayed with nicotine tannate four times during July and August. Observations indicate that the injury occurs when the fruit is young and relatively easily injured. Evidence points to the presence of tannic acid as being responsible for the injury and that an excess of free nicotine in the early cover sprays will reduce the amount of injury.

During the summer of 1932 the Department of Entomology of the New Jersey Agricultural Experiment Station conducted a series of experiments to control codling moth in a heavily infested orchard near Glassboro. A number of materials were tested including (1) the standard lead arsenate treatment, (2) summer oil emulsion and lead arsenate and (3) nicotine tannate. The details concerning the amount of materials used, dates of application and the comparative performance of the different spray mixtures have been reported elsewhere.[1] In general it might be stated that the materials were applied as cover sprays three times during the month of June and four times during July and August to protect the fruit from the first and second broods of codling moth larvae. A mid-season variety (Wealthy) and several late-season varieties (Stayman and Winesap) were included in each block sprayed with the different mixtures.

A peculiar type of injury on the fruit was observed about the first of July on the block sprayed with nicotine tannate. The injury appeared

*Paper of the Journal Series, New Jersey Agricultural Experiment Station, Department of Entomology.

[1]Headlee, Thomas J. Transactions of Peninsula Horticultural Society in Bulletin of the State Board of Agriculture, Camden, Delaware, Vol. 22, No. 5.

as corky, dark brown spots about one to two millimeters in diameter. They were usually located on the underside of the apple where the spray residue was concentrated. An examination of the fruit outside of the nicotine tannate block failed to disclose any similar injury where other spray materials were used. The nicotine tannate block was sprayed three times during June with tank mixed nicotine tannate, the first two applications carrying flotation sulfur as a protection against apple scab. The tannic acid used was an amorphous powder obtained from Chinese gall nuts. In preparing the spray, the powdered tannic acid is dissolved in the spray tank with the agitator running while the tank is being filled. Fifty per cent free nicotine is added just before the tank is full. The charge used was two pounds of the tannic acid powder and one pound of the free nicotine to 100 gallons of water. Since flotation sulfur and free nicotine have both been used rather extensively without the appearance of this particular injury, suspicion was directed to the tannic acid as the cause. It was suggested that possibly part of the tannic acid failed to dissolve and react with the free nicotine and that this free tannic acid in some manner brought about the injury already described. It was also suggested that the tannic acid used in the Glassboro tests may have contained impurities of some kind.

In order to get further information on the cause of the injury it was decided to spray additional blocks during July and August with nicotine tannate made from tannic acid obtained from different sources. An orchard was selected at Moorestown consisting of four rows each of the varieties Wealthy, Stayman and Rome Beauty. The rows averaged 35 trees to a row, making a block of somewhat over 400 trees. This orchard had received four cover sprays for first brood codling moth up to July 11. The first, second and fourth cover sprays consisted of 4 pounds lead arsenate, 9 pounds lime and 1 pound spreader to 100 gallons of water. The third cover spray consisted of 2 pounds lead arsenate, 3 quarts Orthol-K oil and 1 pound spreader to 100 gallons.

Six blocks, each block four rows wide and running across the three varieties, were laid out in the center of the orchard. During the period second brood larvae were hatching these six blocks were sprayed at ten-day intervals on July 11th and 20th and on August 1st and 11th. Blocks 1 and 6 were sprayed on July 11th, 21st and August 11th with lead arsenate 2 pounds, Orthol-K oil 3 quarts and 1 pound of spreader to 100 gallons of water. The cover spray of August 1st on these two blocks consisted of 4 pounds lead arsenate and 1 pound of spreader to 100 gallons of water. Block 2 was sprayed with nicotine tannate, the tannic acid used being an amorphus powder supplied by the Taylor-White Com-

pany of Camden, New Jersey. Block 3 was sprayed with nicotine tannate, using another sample of tannic acid in the form of an amorphus powder. Block 4 was sprayed with nicotine tannate using a liquid tannic acid solution containing 50% tannic acid. Block 5 was sprayed with nicotine tannate also and the tannic acid used was ground Chinese gall nuts. The tannic acid used in blocks 3, 4 and 5 was supplied by Zinsser and Company, Hastings-on-Hudson, New York.

The fruit in the different blocks was examined frequently from mid-July to harvest to determine whether the injury appeared which had been observed earlier at Glassboro. An injury somewhat similar to that which appeared early in the season was observed on two trees (Rome Beauty). Since one of these two was located in block 6 which received no nicotine tannate, it appears that this particular injury was not due to any combination of nicotine and tannic acid. These tests served to show that the particular injury under consideration is less likely to develop when nicotine tannate is applied from mid-season on.

Orchard block tests for codling moth control were run at Glassboro during the season of 1933 on the Stayman variety. One block received nicotine tannate as the insecticide in all cover sprays. This block was sprayed with lead arsenate and commercial lime sulfur at the calyx spray. The first cover spray was applied seven days later and carried nicotine tannate and flotation sulfur. An extra pint of free nicotine was added to each 100 gallons of the nicotine tannate-flotation sulfur to combat aphids. Additional cover sprays of nicotine tannate and bentonite-sulfur were applied at ten day intervals during first brood on this block. About the time the fourth cover spray was applied a few apples were observed which showed the typical injury. Less than one-half of one per cent of the apples in the block were thus affected, therefore, commercially, the injury was negligible.

Certain observations indicate that the injury occurred shortly after the fruit was formed and during the period nicotine tannate was applied at the first and second cover sprays. For example, one tree in the nicotine tannate block was left unsprayed after the first cover spray. (It will be recalled that the first cover spray carried nicotine tannate and flotation sulfur.) Injury on the fruit on this tree was just as pronounced as it was on surrounding trees which received some 8 or 10 additional cover sprays of nicotine tannate. If uncombined tannic acid is responsible in some manner for the injury an explanation for the small amount of injury in the tests this year presents itself. The extra pint of free nicotine used in the first cover spray to combat aphids would tend to tie up any free tannic acid in the tank thus lessening the danger of injury from free tannic acid.

# STUDIES OF THE "RESISTANT" CALIFORNIA RED SCALE *AONIDIELLA AURANTII* MASK. IN CALIFORNIA

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ABSTRACT

A preliminary study of the "resistant" red scale (*Aonidiella aurantii*) of California has been made involving the influence on the kill of the type of hydrocyanic acid concentration, the stage of development of the insect, the temperature of the host, the temperature and relative humidity preceding, during and after the fumigation, and protective stupefaction. It was found that the type of concentration and the percentage of insects in the resistant stages did not determine the effectiveness of the fumigation. Temperature and relative humidity had a decided influence. Protective Stupefaction may or may not be an important factor.

In the early work of fumigating citrus trees with hydrocyanic acid, a failure to control the insects was considered due to faulty work or equipment. In 1922, Quayle (9) presented tests to indicate that in certain areas in California, the red scale was actually more difficult to kill than in certain other areas. Woglum (12) related field results showing that with even more than 100% dosages of hydrocyanic acid, satisfactory kills were not obtained in certain areas.

The trees in these "resistant areas" are infested with what is generally considered a biological race of the California red scale characterized by its ability to withstand even more than 100% dosages of hydrocyanic acid. "Resistance" is generally encountered in the Corona district, the plantings along the southwest side of the Santa Ana Mountains from Tustin northwest to La Habra and Whittier, on the north and south slopes of the Puente Hills and more recently on the hills north of Glendora westward to Azusa. Ebeling (3) has recently pointed out that the "resistant" red scale is in the areas with least danger of frost. These areas are frequently planted to lemons, hence the "resistant" red scale is associated with lemons more commonly than with oranges.

METHODS OF DETERMINING KILLS.—Ebeling (2) has shown that following a fumigation with hydrocyanic acid the best kills will be found on the wood and leaves and the poorest kills on the fruit. Knight (7) has pointed out that in the case of oil sprays poorer kills were obtained on heavily infested fruits than on the lightly infested fruits. He suggests that the same is true of fumigation results. Ebeling (3) also suggests that population density influences fumigation results.

[1]The writer wishes to express his appreciation of the work of J. A. McDonough Harold Orde, Nelson Howard, Jr., J. R. Alcock and Robt. Wathen in making hundreds of chemical analyses and counting over three and a half million red scales in this work.

Table 1 gives the results of counts made in two fumigated orchards. These counts indicate that the density of the population makes no particular difference in the results of the fumigation.

TABLE 1. THE RELATION BETWEEN DENSITY OF POPULATION AND THE KILL

| | La Habra | | | Glendora | | |
|---|---|---|---|---|---|---|
| | Number of lemons | Number of insects | Per cent dead | Number of lemons | Number of insects | Per cent dead |
| Less 100 per lemon... | 104 | 7,003 | 99.21 | 72 | 4,172 | 97.63 |
| 100–199 per lemon.... | 168 | 24,892 | 99.73 | 93 | 13,727 | 96.18 |
| 200–299 per lemon.... | 97 | 23,700 | 99.87 | 87 | 21,217 | 97.06 |
| 300–399 per lemon.... | 60 | 22,670 | 99.64 | 71 | 27,714 | 96.87 |
| 400 or more per lemon | 38 | 26,172 | 99.85 | 156 | 78,877 | 96.78 |
| | 467 | 104,437 | 99.74 | 479 | 145,707 | 96.87 |

In the work reported in this paper, lemons with a dense scale population were generally used. Sufficient lemons were used in each set to make a total of 5000 to 20,000 insects. The probable error in the kill was determined, after the natural mortality was deducted, by the formula given by Hartzell (5).

$$\text{Per cent kill} = 100\ p \pm 67.449\sqrt{\frac{\bar{p}\,\bar{q}}{N}}$$

$\bar{p}$ = percentage of dead scale, $\bar{q}$ percentage of live scale, N = total number of insects. In comparing two sets, the observed per cent kill with its probable error determined by the above formula was compared with the expected per cent kill with its probable error determined by the formula

$100\ \bar{p} \pm 67.449\sqrt{\bar{p}\,\bar{q}\left(\frac{1}{N_2}+\frac{1}{N_1}\right)}$, $N_1$ being the number of insects in the standard and $N_2$ the number of insects in the set being compared with the standard. Either set being compared may be used as the standard.

INFLUENCE OF THE TYPE OF CONCENTRATION ON THE KILL.—There have been many changes in the materials used and their method of application since the beginning of fumigation with hydrocyanic acid in California. An idea persists among fumigators and growers that the results would be better than they are today if old materials and methods were used.

The first hydrocyanic acid was generated in an earthenware jar from potassium cyanide and dilute sulphuric acid. Woglum (10) states that when he came to California, he found the fumigators using from 2 to 8

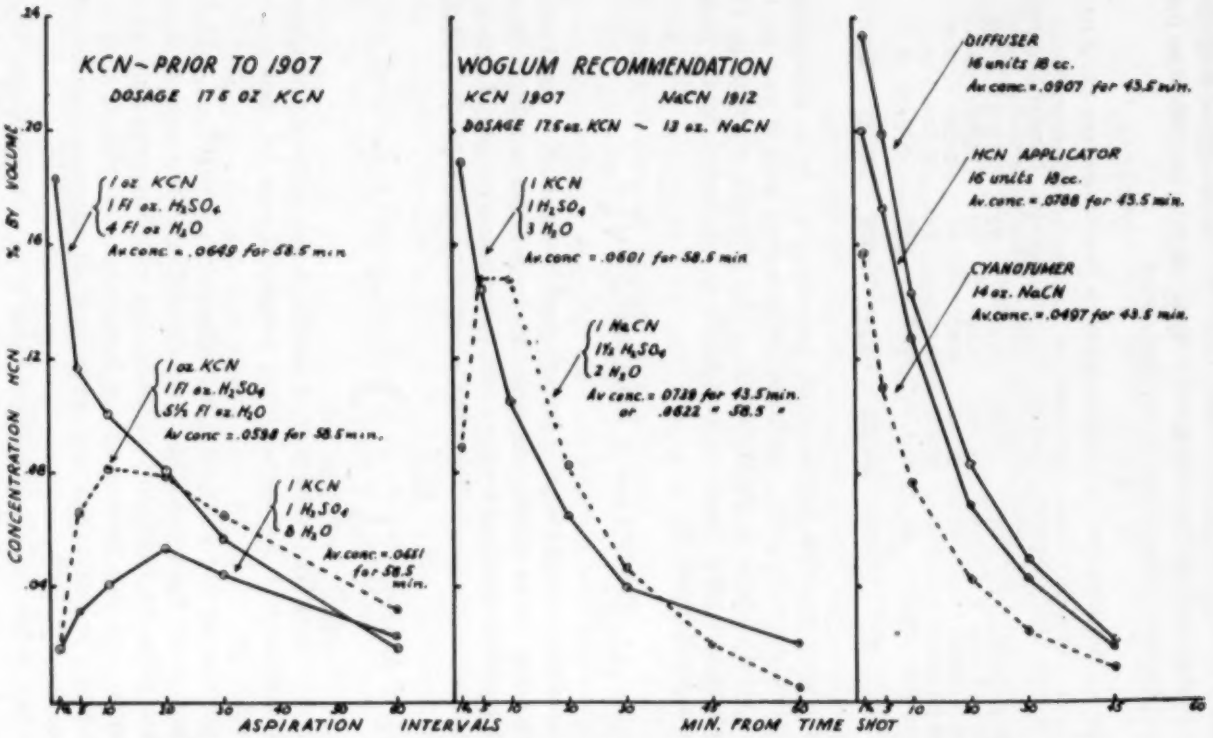


FIG. 107.—Concentrations of hydrocyanic acid by different methods used in California at different times.

fluid ounces of water to each fluid ounce of sulphuric acid. He found 2 fluid ounces of water too small a quantity to dissolve the potassium sulphate formed by the reaction and that with larger amounts of water the percentage of hydrocyanic acid generated from the potassium cyanide was diminished. He selected the 1–1–3 formula as most suitable. In a later paper, Woglum (11) discussed sodium cyanide and gave the formula for its use as 1–1½–2. The Cyanofumer followed shortly after the introduction of sodium cyanide. In this machine, the sodium cyanide was dissolved in water and by the working of a lever, a definite amount of sodium cyanide solution was dumped into the large generator containing the acid. The gas was given off with a rush and the machine passed on to the next tree. Liquid Hydrocyanic acid followed the Cyanofumer. It is applied in two ways. One method, known locally as "cold gas," consists of atomizing the liquid through spray nozzles under the tent. The other method, known as "hot gas," passes the measured amount of liquid through coils heated with steam at 20 lbs. pressure. These heated coils vaporize the liquid and the gas under pressure is delivered through a distributing nozzle. This is called a Diffuser.

Working with a form tent of approximately 2000 cu. ft. capacity, 38 ft. over and 44 ft. around (16 unit size), a study has been made of the types of concentration obtained by the different methods and with the different dosages. Concentration curves for the different methods and dosages are shown in Fig. 107. It will be noted that in early fumigation practice, due to the use of large quantities of water, a gradual evolution of the gas was obtained. The entire course of development of fumigation practice has been away from this type of concentration toward a high concentration quickly obtained. With a peak concentration quickly reached and no gas given off after the start, to replace that loss by tent leakage, the concentration drops rapidly. This factor resulted in lowering the fumigation period from one hour to 45 minutes. With the Cyanofumer all the gas was released at once. This machine gave the lowest concentrations of any of the methods, due to the retention of gas in the acid mixture in the generator. The amount of this gas was so large that when the spent generator was dumped, the mixture could be ignited. The use of "hot gas" in the Diffuser gave the highest concentration evenly distributed in the shortest period of time.

Knight (6) has pointed out that the kill of insects is related to a constant obtained by multiplying the concentration of gas by the length of exposure. Brinley and Baker (1), working with other insects, have found the same relationship. Taking the known concentrations from the preceding curves, that is, from 1½ min. after the application to the end

of the period, the following constants were obtained for the various methods:

| | | | |
|---|---|---|---|
| 3.22 for KCN 1–1–8 | 58.5 | min. | period |
| 3.50 for KCN 1–1–5½ | " | " | " |
| 3.79 forKCN 1–1–4 | " | " | " |
| 3.52 for KCN 1–1–3 | " | " | " |
| 3.64 for NaCN 1–1½–2 | " | " | " |
| 3.45 for NaCN 1–1½–2 | 43.5 | " | " |
| 2.16 for Cyanofumer | " | " | " |
| 3.41 for Liquid HCN applicator | " | " | " |
| 3.95 for Liquid HCN Diffuser | " | " | " |

The constant varies from 2.16 to 3.95 with an average of 3.4.

In the case of the Cyanofumer and the Diffuser, the dosage is well distributed throughout the tent almost at once, hence the first 1½ minutes should be considered. Projecting the concentration from 1½ min. to the start, the constant for the Cyanofumer becomes 2.4 instead of 2.16 and for the Diffuser 4.31 instead of 3.95. With these corrections, the average constant becomes 3.47. These figures indicate that during the history of fumigation in California, although different dosages and materials and methods of application have been used, the constant, time x concentration, has varied but little.

Gray and Kirkpatrick (4) found that exposure of red scale to low concentrations of hydrocyanic acid created a condition in the insects making them more difficult to kill. This effect they named "protective stupefaction." This condition may be brought about in two ways. The insects on near-by trees may be exposed to gas leaking from the tents during a fumigation. This is known as drift gas and many field tests have shown this to be the chief cause of poor kills resulting from stupefaction. The other cause of stupefaction is the exposure of the insects to sub-lethal concentrations due to faulty distribution of the gas within the tent during the fumigation. Faulty distribution of the gas may result from the use of "cold gas" during winter daylight fumigation when the temperature of the soil is much lower than the air temperature. The evaporation of the atomized liquid hydrocyanic acid produces a cooling effect causing the gas to stratify at the bottom of the tent. If the soil is warmer than the air, the usual condition during night fumigation, the gas is carried up by convection currents arising from the warmer soil. If the soil is cooler than the air, the gas remains at the bottom of the tent and the upper parts of the tree are exposed to low and irregular concentrations. To overcome this difficulty, the Diffuser is

used which not only delivers the hydrocyanic acid under the tree as a gas but also gives an immediate uniform distribution of the gas under the

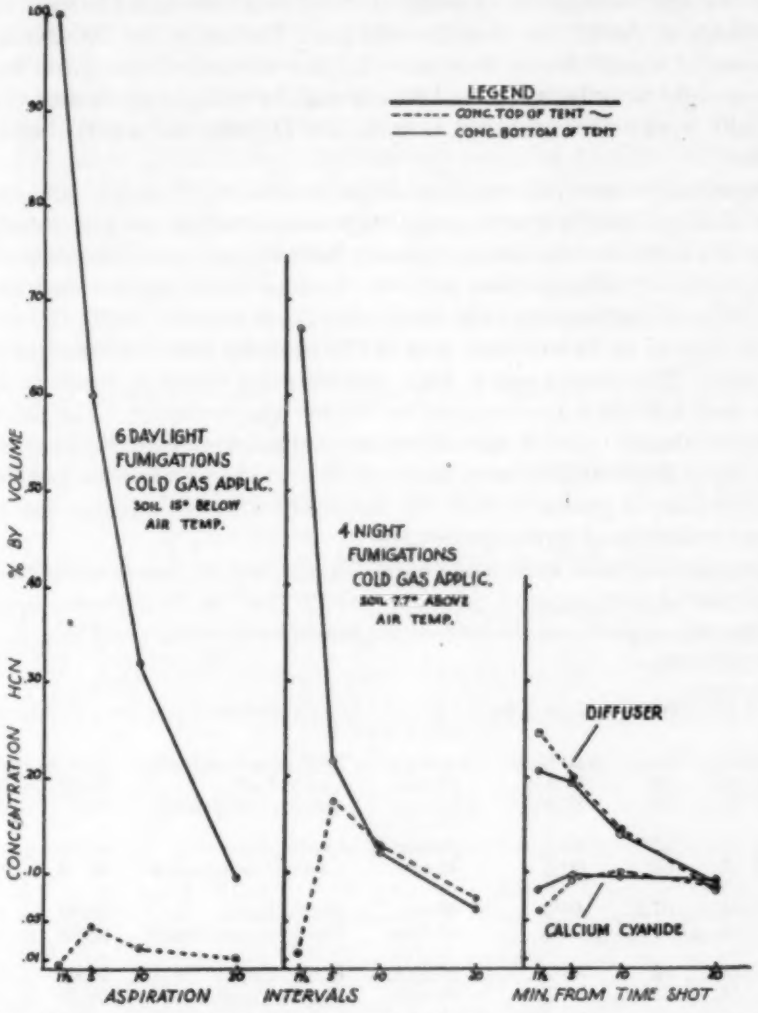
LEGEND
CONC. TOP OF TENT
CONC. BOTTOM OF TENT
CONCENTRATION HCN % BY VOLUME
6 DAYLIGHT FUMIGATIONS COLD GAS APPLIC. SOIL 15° BELOW AIR TEMP.
4 NIGHT FUMIGATIONS COLD GAS APPLIC. SOIL 7.7° ABOVE AIR TEMP.
DIFFUSER
CALCIUM CYANIDE
ASPIRATION INTERVALS
MIN. FROM TIME SHOT

FIG. 108.—Concentrations of hydrocyanic acid at the top and bottom of the tent under different soil conditions and methods.

tented surface. Fig. 108 shows the gas concentrations at the top and bottom of the tent for the atomized liquid hydrocyanic acid during unfavorable and favorable conditions and the uniform distribution of gas when vaporized and distributed by the Diffuser.

Gray and Kirkpatrick (4) considered protective stupefaction due to faulty gas distribution more wide-spread than has been shown to be the case. In night fumigation, carefully checked tests have failed to show an advantage of the hot gas over the cold gas. The use of the Diffuser by commercial fumigators for four years has not shown a consistent difference in night work between the Diffuser and the cold gas applicator. In daylight work, where the soil is cold, the Diffuser has shown better results.

Experiments were performed to determine the effect of changing the type of concentration from a quick, high concentration quickly leaking away to a lower concentration gradually built up and better maintained. Both types of concentration may be obtained from calcium cyanide. One form of calcium cyanide containing approximately 50% CN releases most of its hydrocyanic acid at the time the dust is blown under the tent. This gives a quick, high concentration which is quickly lost since tent leakage is not replaced by further gas evolution. The other form of calcium cyanide containing approximately 25% CN gives off only about 30%–40% of its hydrocyanic acid in the first minute and the concentration is gradually built up during the first ten minutes due to further evolution of hydrocyanic acid.

Comparative tests were made upon orange trees at Azusa using such quantities of each type of calcium cyanide that its hydrocyanic acid content was approximately 50% of the liquid hydrocyanic acid schedule for California.

TABLE 2. COMPARISON OF TWO TYPES OF CONCENTRATION FROM TWO FORMS OF CALCIUM CYANIDE

| Time | Temp. | Rel. Hum. | Exposure | Type of concentration | Kill on fruit |
|---|---|---|---|---|---|
| 7.30 P.M. | 53° | 87.5% | 45 min. | Quick, high | 98.02% ±.30 |
| 7.30 P.M. | 53° | 87.5% | 45 min. | Gradual maintained | 99.72 ±.07 |
| 3.10 P.M. | 63° | 60% | 45 min. | Quick, high | 97.72 ±.19 |
| 3.10 P.M. | 63° | 60% | 45 min. | Gradual maintained | 98.74 ±.13 |
| 4.30 P.M. | 67.5° | 48% | 45 min. | Quick, high | 98.92 ±.19 |
| 4.30 P.M. | 67.5° | 48% | 45 min. | Gradual maintained | 98.32 ±.14 |
| 4.32 P.M. | 62° | 38% | 45 min. | Quick, high | 97.91 ±.20 |
| 4.32 P M. | 62° | 38% | 45 min. | Gradual maintained | 99.00 ±.10 |

In three of the four tests, the differences were in favor of the lower concentration maintained rather than the quick, high concentration. These differences may not be due to the type of concentration but due to the loss of hydrocyanic acid at the time of application. When a calcium cyanide dust is blown under a tent a considerable volume of air is introduced by the blower resulting in air being forced out of the tent.

Using a material with a rapid evolution of gas, considerable hydrocyanic acid is lost immediately, thus reducing the effective dosage.

Comparisons were made between liquid hydrocyanic acid producing a quick high concentration and calcium cyanide distributed on the ground by means of a shaker, giving a low, well maintained concentration. This method of using calcium cyanide gives a concentration curve similar to the KCN curve where extra water was added to the acid. Unlike the KCN curve, it has a very uniform concentration in different parts of the tent. (Fig. 108.) In using calcium cyanide the exposures were 1–1½ hours comparable to the customary exposures with KCN; with liquid hydrocyanic acid, the exposure was for 45 minutes, comparable to the present day practice. In these tests, the same quantity of hydrocyanic acid was used either in the form of liquid or calcium cyanide. The first tests were on lemon trees at La Habra.

TABLE 3. COMPARISON OF CONCENTRATION FROM CALCIUM CYANIDE AND LIQUID HCN

| Time | Condition | Material | Kill |
|---|---|---|---|
| 6 P.M. | Temp. 64° Rel. Hum. 74% Soil 66°–76° | Liquid HCN 100% dosage Cold Gas applicator 45 min. exposure | 99.05%±.03 |
| | | Calcium cyanide applied on ground 1½ hrs. exposure. Equivalent to 100% liquid dosage | 99.03%±.15 |
| 6.14 P.M. | Temp. 61° Rel. Hum. 89% Soil 64°–73° | Liquid HCN 100% dosage Cold Gas applicator 45 min. exposure | 99.41%±.1 |
| | | Calcium cyanide applied on ground. 1½ hrs. exposure. Equivalent to 100% liquid dosage | 99.06%±.12 |

Another test was made November 22, 1932 at Glendora under conditions giving poor kills.

TABLE 4. COMPARISON OF DIFFERENT TYPES OF CONCENTRATION

| Time P. M. | Temp. | Rel. Hum. | Soil | Material | Dosage | Exposure | Kill |
|---|---|---|---|---|---|---|---|
| 3.40 | 72° | 34% | 70–72° | Cold gas | 100% | 45 min. | 87.91%±.55 |
| 3.40 | 72° | 34% | 70–72° | Hot gas | 100% | 45 min. | 93.88%±.45 |
| 3.50 | 70° | 40% | 70–72° | Calcium cyanide | 100% | 1½ hrs. | 93.45%±.37 |
| 3.55 | 70° | 40% | 70–72° | Calcium cyanide | 100% | 1 hr. | 93.11%±.38 |
| 4.30 | 65° | 44% | 68–71° | Cold gas | 100% | 45 min. | 88.42%±.55 |
| 4.30 | 65° | 44% | 68–71° | Hot gas | 100% | 45 min. | 87.94%±.54 |

A significantly better kill was obtained by the use of the Diffuser over the kill with cold gas when the soil temperature was the same or lower than the air temperature but there was no difference between the results obtained with either the cold gas or the hot gas when the soil temperature was above the air temperature. There was no significant difference in

the results from calcium cyanide applied on the ground and the liquid hydrocyanic acid applied with the Diffuser at the same time. The con-

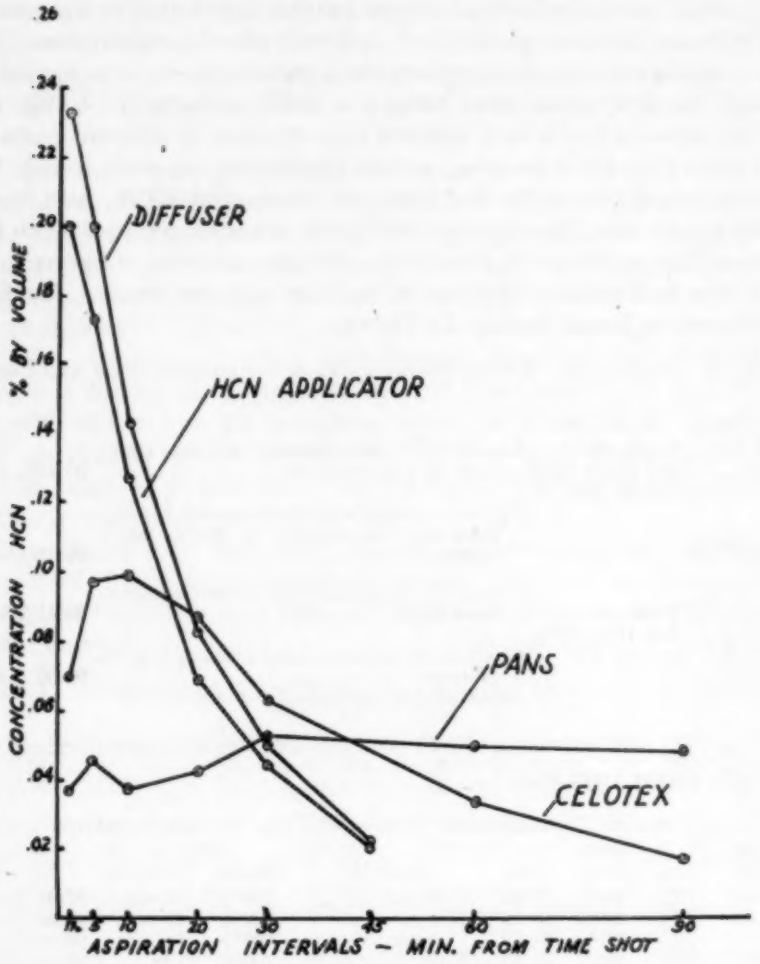


FIG. 109.—Concentrations obtained in applying liquid hydrocyanic acid by different methods.

centration curves from these two materials are entirely different (Fig. 108). Soil and air temperature relations, unfavorable to the use of liquid hydrocyanic acid by the cold gas applicator, were not unfavorable to the use of calcium cyanide.

Another method of changing the type of concentration is to remove the nozzles from the regular liquid applicator and pump the dosage out upon porous Celotex or into pans placed under the tent. The liquid hydrocyanic acid evaporating from either the Celotex or the pans gives an entirely different concentration than is obtained by either the cold or hot gas application. (Fig. 109.) Fumigation by these methods for 90 minutes produces time x concentration constants comparable to those from regular methods for 45 minutes.

| | | | |
|---|---|---|---|
| Diffuser | 43.5 | min. | = 3.95 |
| Liquid application | 43.5 | " | = 3.41 |
| Pumped onto Celotex | 88.5 | " | = 3.38 |
| Pumped into pans | 88.5 | " | = 4.28 |

Tests of these methods were made at La Habra October 6 and 8, 1932.

TABLE 5. COMPARISON OF DIFFERENT TYPES OF CONCENTRATION FROM LIQUID HCN

| Time | Temp. | Rel. Hum. | Soil | Method | |
|---|---|---|---|---|---|
| 6.37 P.M. | 61° | 89% | 64–73° | Regular cold gas applicator | 99.40%±.10 |
| 6.30 P.M. | 61° | 89% | 64–73° | Evaporating from Celotex | 99.02%±.14 |
| 6.33 P.M. | 61° | 89% | 64–73° | Evaporating from pans | 97.62%±.25 |
| 6.32 P.M. | 61° | 78% | 64–71° | Regular cold gas applicator | 99.67%±.16 |
| 6.13 P.M. | 61° | 78% | 64–71° | Diffuser | 99.59%±.10 |

These results confirm the former tests, that the type of concentration makes no significant difference providing there is no faulty distribution of the gas. The slow evaporation from the pans gave abundant opportunity for protective stupefaction, since the concentration was low throughout the test. This is reflected in the kill by this method.

The conclusion is reached that, providing proper distribution of the gas is obtained within the tent, the type of concentration curve has no significant influence on the kill. The low concentration gradually rising, as with calcium cyanide applied on the ground or liquid hydrocyanic acid evaporating from a porous material, gave the same results as the quick, high concentration of the Diffuser. This was observed under conditions giving low, as well as high, kills.

In order to determine the advantages of low concentration or high concentration, laboratory tests were made under controlled conditions. For these tests, the metal box described by Gray and Kirkpatrick (4) was used. Certain changes were made in the set-up. Metallic mercury was substituted for the oil seal. In applying the dosage, the liquid hydrocyanic acid was first measured into a little chamber, instead of the flask, and the entire dosage was then dropped into a coil heated with

boiling water. By this method, the entire dosage was blown into the box in a few seconds and uniform distribution was assured by means of a fan. This procedure permitted short exposures with high concentrations since all concentrations reached their maximum in all parts of the box in a matter of seconds.

The fumigations were carried out on lemons collected at Corona, the area in which "resistant" red scale was first found. The lemons were attached by wires to iron stands so that no lemon touched another lemon

TABLE 6. KILLS OBTAINED BY DIFFERENT TIME-CONCENTRATION CONSTANTS

| Time in minutes | Concentration per cent by volume | Exposure x concentration | Kill | |
|---|---|---|---|---|
| 60 | .2013 | 12.078 | 100.00% | |
| 7 | 1.4843 | 10.390 | 98.95 | ±.30 |
| 45 | .1597 | 7.186 | 98.88 | ±.33 |
| 90 | .0698 | 6.282 | 98.29 | ±.47 |
| 10 | .5865 | 5.865 | 99.01 | ±.30 |
| 5 | 1.1549 | 5.774 | 100.00 | |
| 90 | .0602 | 5.418 | 95.40 | ±.68 |
| 60 | .0779 | 4.974 | 99.89 | ±.11 |
| 10 | .4865 | 4.865 | 99.73 | ±.15 |
| 45 | .1080 | 4.860 | 96.63 | ±.65 |
| 30 | .1619 | 4.857 | 95.87 | ±.67 |
| 90 | .0516 | 4.644 | 91.77 | ±.86 |
| 20 | .2288 | 4.576 | 98.52 | ±.40 |
| 5 | .9028 | 4.514 | 96.72 | ±.59 |
| 90 | .0438 | 3.942 | 97.16 | ±.52 |
| 45 | .0861 | 3.874 | *100.00 | |
| 90 | .0294 | 2.646 | 96.51 | ±.55 |
| 90 | .0220 | 1.978 | †98.99 | ±.38 |

*18 cc schedule with Diffuser under tent.
†Calcium cyanide under tent.

or any other object, thus exposing all insects equally. Concentrations from 1.48% to .0294% by volume and time periods of 5 to 90 minutes were used. Fumigations were made between Dec. 19 and Dec. 31, 1932, between the hours of 10 A. M. and 4 P. M. The temperature range was 53°–70° F., under conditions considered as favorable for daylight winter fumigation. In addition to the metal box fumigations, two runs were made in the form tent, one using liquid hydrocyanic acid applied with the Diffuser and the other with a low concentration obtained from calcium cyanide applied on the ground. The results of the series are given in Table 6. This table is arranged in the order of time x concentration constant.

There is no regularity of results even considering a definite time interval. Many of these dosages are far above the tree tolerance and yet perfect kills were not obtained. The results do not discredit the time x concentration constant but merely indicate that there was some un-

controlled factor influencing the success of a fumigation which overshadowed the time x concentration constant. In other words, if conditions are unfavorable, increasing the dosage or the time will not insure a perfect kill.

Preceding each of the fumigations, a set of lemons was prefumigated with a concentration of .015 to .02% by volume for a period of 20 min., to produce protective stupefaction. These prefumigated lemons were then fumigated along with others not prefumigated, in the same box. In Table 7, the two sets of lemons are arranged first according to length of exposure and second according to the kill of insects not prefumigated.

TABLE 7. THE EFFECT OF EXPOSING "RESISTANT" RED SCALE TO A LOW CONCENTRATION

| Time | Concentration per cent by volume | Not pre-fumigated | Pre-fumigated | Kill |
|---|---|---|---|---|
| 5 | 1.1549 | 100.00% | 98.48%±.4 | —1.52* |
| 5 | .9028 | 96.72 ±.59 | 97.69 ±.45 | +0.97 |
| 30 | .1619 | 95.87 ±.67 | 98.73 ±.38 | +2.86 |
| 45 | .1597 | 98.88 ±.33 | 99.31 ±.26 | +0.43 |
| 45 | .1080 | 96.63 ±.65 | 98.71 ±.31 | +2.08 |
| 45 | .0861 | 100.00 | 98.58 ±.35 | —1.42* |
| 60 | .2013 | 100.00 | 99.72 ±.1 | —0.28 |
| 60 | .0779 | 99.89 ±.11 | 98.17 ±.4 | —1.72 |
| 90 | .0602 | 95.40 ±.68 | 97.89 ±.42 | +2.49 |
| 90 | .0516 | 91.77 ±.86 | 98.58 ±.48 | +6.81* |
| 90 | .0220 | 98.99 ±.38 | 91.42 ±.90 | —7.57* |
| | | 100.00% | 98.48% | —1.52%* |
| | | 100.00 | 99.72 | —0.28 |
| | | 100.00 | 98.58 | —1.42* |
| | | 99.89 | 98.17 | —1.72* |
| | | 98.99 | 91.42 | —7.57* |
| | | 98.88 | 99.31 | +0.43 |
| | | 96.72 | 97.69 | +0.98 |
| | | 96.63 | 98.71 | +2.08 |
| | | 95.87 | 98.73 | +2.86 |
| | | 95.40 | 97.89 | +2.49 |
| | | 91.77 | 98.78 | +6.81* |

*Indicates significant differences.

Under conditions giving high kills prefumigation reduced the kill. Above 98% there were 4 significant negative differences and two without differences. Below 98%, the differences are all positive but only one is significant. These results indicate that exposure to low concentrations preceding the regular fumigation does not always reduce the kill and field results confirm these conclusions.

THE INFLUENCE OF STAGES OF DEVELOPMENT UPON THE KILL.—Unpublished studies by several entomologists have indicated that certain stages of the "resistant" red scale are more difficult to kill than others. This was particularly true for the late second molt and the early grey

adult. The question arises as to whether the kill obtained in actual orchard fumigation is related to the percentage of the scale in these stages of development.

The following field fumigations are arranged to show this relationship if it exists.

TABLE 8. INFLUENCE OF PERCENTAGE OF RESISTANT STAGES UPON THE KILL

| Per cent resistant stages | Place | Kill |
|---|---|---|
| 14.50 | Glendora | 50.94%–94.04% |
| 14.89 | Corona | 100% |
| 19.20 | La Habra | 99.51% |
| 22.80 | La Habra | 98.06% |
| 24.50 | La Habra | 99.81% |
| 45.50 | Corona | 89.03%–95.97% |
| 56.00 | Corona | 95.69% |

Where different kills are indicated as at Glendora and Corona, they represent the highest and lowest in a series of fumigations on the same day. Clearly the stage of development is not the controlling factor when, with the same dosage and without a drift gas effect, the kill can vary from 50% to 94% in the same day. Live insects which were in these resistant stages at the time of fumigation are more frequently encountered than others. It would appear as if conditions at the time of the fumigation decide its success or failure and the stage of development of the insect decides whether it will or will not be a survivor of an unsuccessful fumigation.

INFLUENCE OF THE TEMPERATURE OF THE LEMON UPON THE KILL.—During the box fumigations recorded in Table 6, the nights were generally cold. It was observed that in general better kills were obtained in

TABLE 9. A COMPARISON OF THE FUMIGATION OF INSECTS KEPT UNDER COOL AND WARM CONDITIONS PRECEDING THE FUMIGATION

| Time | Concentration per cent by volume | Lemons from warm room | Lemons from outside |
|---|---|---|---|
| 9.22 A.M. | .0367 | 62.32%±1.37 | 84.33%±1.00 |
| 10.22 A.M. | .0807 | 93.65%± .54 | 97.75%± .43 |
| 11.19 A.M. | .0613 | 87.70%± .81 | 92.87%± .74 |
| 1.11 P.M. | .0508 | 80.69%±1.16 | 94.00%± .57 |
| 2.09 P.M. | .0331 | 79.35%±1.2 | 77.76%±1.03 |
| 3.08 P.M. | .0934 | 96.93%± .42 | 97.68%± .35 |

the afternoon, particularly late afternoon than earlier in the day. Following a cold night, it might be that a number of hours of increased temperature were necessary to activate the insects. Then insects on lemons kept during the night in a warm room should be easier to kill than those on lemons exposed to the normal low night temperatures when fumi-

gated together. Lemons for this experiment were obtained from Corona. They were divided into two lots, one being placed in a room heated to 70°–75° F., the other exposed to normal night temperatures. The following day a series of 45 min. fumigations was conducted in the metal box with different concentrations.

The first four tests showed significant differences, the last two no differences. In attempting to determine how long a period of heating was necessary to produce these results, it was found that there was a lag in the temperature of the lemon compared with the air temperature. A lemon at a temperature of 51.8° F., brought into a room heated to 75° F., showed a temperature of 64° at the end of 1 hour, 67° at 2 hours, 72.5° at 3 hours and 4 hours.

TABLE 10. THE RESULTS OF FUMIGATING LEMONS AT DIFFERENT TEMPERATURES ABOVE THE AIR TEMPERATURE

| Degrees lemon temperature above air temperature | Kill | Degrees lemon temperature above air temperature | Kill |
|---|---|---|---|
| 11.4° | 94.36% | 2.5° | 80.08% |
| 9.0 | 94.93 | 2.3 | 88.37 |
| 8.0 | 88.98 | 1.7 | 95.02 |
| 7.6 | 96.05 | 1.6 | 92.51 |
| 7.5 | 88.99 | 1.6 | 98.67 |
| 5.6 | 67.38 | 0.7 | 97.61 |
| 5.1 | 86.36 | 0.5 | 95.60 |
| 3.5 | 91.14 | 0.5 | 97.22 |
| 3.1 | 98.16 | 0.4 | 97.68 |
| 2.6 | 93.26 | 0.2 | 95.91 |

A series of 45 minute fumigations was made with Corona lemons all at approximately the same concentration .0802 to .0870% by volume. Fumigations were carried out on two days at different times of the day and night. Lemons used in these tests were all at different temperatures higher than the temperature of the fumigation chamber.

In general, the greater the difference between the lemon temperature and the box temperature the lower the kill. This is apparently a factor of some importance.

An experiment similar to that of Table 9 was repeated with lemons of known temperatures. In carrying out this test lemons were obtained from Corona to represent "resistant" red scale and from La Canada to represent "non-resistant" red scale. Sets of each were fumigated together.

Different kills are apparent in these sets but they are not correlated with the magnitude of the difference between the temperature of the lemon and the air temperature. The "non-resistant" insects from La Canada showed little reaction to changed temperature conditions.

Lemons under actual fumigation conditions may be at higher or lower temperatures than the air temperature due to sudden changes in

TABLE 11. THE SIMULTANEOUS FUMIGATION OF WARM AND COOL LEMONS WITH "RESISTANT" AND "NON-RESISTANT" RED SCALE

| Time | Concentration per cent by volume | Degrees difference lemons minus air temperature | Kill of insects on Corona lemons | Kill of insects on La Canada lemons |
|---|---|---|---|---|
| 9.16 A.M. | .0729 | + 13.0 | 63.45%± .71 | 94.75%±.48 |
| | | — 6.4 | 78.26%±2.37 | 96.89%±.40 |
| 10.46 A.M. | .0608 | + 2.3 | 36.88%±2.57 | 97.54%±.36 |
| | | — 4.0 | 87.59%±2.68 | 94.71%±.52 |
| 3.15 P.M. | .0589 | + 8.0 | 51.88%±2.67 | 99.88%±.08 |
| | | — 1.0 | 77.05%±2.57 | 100.00% |
| 5.20 P.M. | .0683 | +15.8 | 71.70%±2.41 | 100.00% |
| | | + 1.8 | 89.57%±1.92 | 100.00% |
| 8.51 A.M. | .0977 | +15.1 | 96.09%± .69 | 100.00% |
| | | + 4.3 | 97.33%± .59 | 99.82%±.08 |
| | | — 6.5 | 99.72%± .21 | |
| 2.11 P.M. | .0984 | + 6.5 | 98.88%± .38 | 99.91%±.08 |
| | | + 4.5 | 96.37%± .67 | 98.76%±.29 |
| | | — 5.4 | 98.06%± .49 | 99.73%±.18 |
| 8.30 P.M. | .0815 | +24.2 | 97.77%± .53 | 99.79%±.14 |
| | | — 1.9 | 96.37%± .67 | 99.51%±.19 |
| | | — 2.8 | 94.90%± .79 | 99.66%±.16 |

the air temperature or to the sun shining upon the lemon. A fumigation was conducted at Glendora at different times of day and night. The lemons were picked so as to represent those in the sunshine during the day for comparison with those in the shade. Natural mortality counts were made on the same basis.

TABLE 12. THE FUMIGATION OF LEMONS IN THE SUN AND SHADE PRECEDING TREATMENT

| Time | Lemons in sun during day Lemon temp. minus air temp. | Kill | Lemons in shade during day Lemon temp. minus air temp. | Kill |
|---|---|---|---|---|
| 5.08 P.M. | + 2.7° | 80.75%±.70 | +2.7° | 78.19%±.72 |
| 11.00 A.M. | +10.6 | 99.26%±.19 | —2.0 | 96.90%±.38 |
| 1.00 P.M. | +10.6 | 94.38%±.55 | +2.2 | 98.78%±.19 |
| 3.00 P.M. | + 9.5 | 89.37%±.68 | +1.4 | 96.34%±.47 |
| 5.00 P.M. | + 9.3 | 98.79%±.23 | +3.0 | 97.85%±.41 |
| 3.00 P.M. | +12.2 | 96.75%±.46 | +1.4 | 96.08%±.48 |
| 4.00 P.M. | +11.7 | 97.09%±.39 | +1.8 | 99.80%±.10 |
| 5.00 P.M. | + 8.6 | 96.41%±.48 | +2.9 | 98.57%±.28 |
| 6.00 P.M. | + 5.2 | 96.09%±.38 | +0.9 | 89.13%±.70 |
| 9.00 P.M. | — 2.0 | 94.62%±.49 | —1.7 | 89.59%±.66 |
| Natural mortality..... | | 93.59%±.12 | | 94.01%±.11 |

In five cases the lemons at the higher temperature had the poorest kill and in two cases, those with the lower temperature showed the poorest kill. In two cases there was no difference.

It would appear from the data presented that the temperature of the lemon compared with the air temperature is not the controlling factor in

the kill. Under conditions giving poor kills the lemons showing the greater positive temperature differences exhibited the lower kills.

INFLUENCE OF TEMPERATURE AND RELATIVE HUMIDITY UPON THE KILL.—The effect of temperature and relative humidity was the subject

TABLE 13. FUMIGATION OF "RESISTANT" RED SCALE AT DIFFERENT TEMPERATURES

| Concentration per cent by volume | Time | Temperature | Rel. Hum. | Kill |
|---|---|---|---|---|
| .0802 | 2.00 P.M. | 64.0° | 51.0% | 87.88% |
| .0854 | 4.00 P.M. | 62.0 | 52.0 | 89.96 |
| .0820 | 5.00 P.M. | 58.5 | 32.5 | 92.51 |
| .0815 | 8.30 P.M. | 58.5 | 44.0 | 94.90 |
| .0859 | 6.00 P.M. | 55.5 | 40.0 | 88.37 |
| .0849 | 7.00 P.M. | 55.5 | 36.0 | 95.02 |
| .0867 | 9.00 A.M. | 54.0 | 64.0 | 87.50 |
| .0848 | 8.00 P.M. | 54.0 | 35.0 | 97.68 |
| .0853 | 9.00 P.M. | 53.5 | 33.0 | 95.60 |
| .0845 | 10.00 P.M. | 53.5 | 28.8 | 97.22 |
| .0828 | 1.00 A.M. | 53.5 | 23.8 | 98.67 |
| .0807 | 10.22 A.M. | 53.0 | 60.3 | 97.73 |
| .0845 | 12.00 P.M. | 52.0 | 29.0 | 97.61 |
| .0836 | 11.00 P.M. | 51.5 | 36.9 | 95.91 |
| .0836 | 3.00 A.M. | 44.0 | 52.5 | 98.16 |

TABLE 14. FUMIGATION WITH LOW CONCENTRATION OF "RESISTANT" AND "NON-RESISTANT" RED SCALE AT DIFFERENT TEMPERATURES

| Concentration per cent by volume | Time | Temp. | Rel. Hum. | Kill of resistant red scale | Kill of non-resistant red scale |
|---|---|---|---|---|---|
| .0633 | 12.44 P.M. | 75° | 27% | 56.05% | 99.45% ±.21 |
| .0591 | 1.32 P.M. | 70 | 33 | 91.04 | 99.18 ±.28 |
| .0589 | 1.45 P.M. | 66 | 36 | 56.60 | 98.90 ±.23 |
| .0589 | 3.15 P.M. | 66 | 36 | 77.05 | 100.00 |
| .0629 | 10.19 A.M. | 66 | 36 | 89.69 | —— |
| .0578 | 12.15 P.M. | 64 | 38 | 65.71 | 98.91 ±.24 |
| .0608 | 10.46 P.M. | 62 | 45 | 87.59 | 94.71 ±.52 |
| .0564 | 12.49 P.M. | 62 | 91 | 88.49 | —— |
| .0508 | 1.11 P.M. | 60 | 48 | 94.00 | —— |
| .0575 | 10.22 A.M. | 59 | 62 | 92.89 | —— |
| .0683 | 5.20 P.M. | 59 | 52 | 89.57 | 100.00 |
| .0608 | 8.51 P.M. | 58 | 54 | 90.98 | 99.67 ±.15 |
| .0613 | 11.19 A.M. | 56 | 55 | 92.83 | —— |
| .0598 | 9.35 P.M. | 55 | 43 | 95.69 | 100.00 |

of study in a number of 45 minute fumigations during the winter of 1932–33 with "resistant" insects from the same orchard in Corona. Different concentrations were used at different times. Concentrations nearly equal and produced by the same dosage of hydrocyanic acid were arranged according to the temperature at which the fumigation was conducted. Tables 13 and 14 give the results for two different concentrations arranged according to the temperature. Table 14 also contains

the results with "non-resistant" red scale from La Canada fumigated with the "resistant" red scale from Corona.

A general upward trend in kill is noted with lower temperatures. There also appears to be a relationship between the kill and the time of day. In Table 13 at the same temperature of 54° and on the same day the kill is much better at 8 P. M. than at 9 A. M. The same set of figures shown in Table 14 is rearranged in Table 15 upon the basis of relative humidity.

TABLE 15. INFLUENCE OF RELATIVE HUMIDITY

| Concentration per cent by volume | Time | Temperature | Rel. Hum. | Kill |
|---|---|---|---|---|
| .0564 | 12.49 P.M. | 62° | 91% | 88.49% |
| .0575 | 10.22 A.M. | 59 | 62 | 92.89 |
| .0613 | 11.19 A.M. | 56 | 55 | 92.83 |
| .0608 | 8.51 P.M. | 58 | 54 | 90.98 |
| .0683 | 5.20 P.M. | 59 | 52 | 89.57 |
| .0508 | 1.11 P.M. | 60 | 48 | 94.00 |
| .0608 | 10.46 A.M. | 62 | 45 | 87.59 |
| .0598 | 9.35 P.M. | 55 | 43 | 95.69 |
| Average | | | | 91.50% |
| .0578 | 12.15 P.M. | 64° | 38% | 65.71% |
| .0629 | 10.19 A.M. | 66 | 36 | 89.69 |
| .0589 | 1.45 P.M. | 66 | 36 | 56.60 |
| .0589 | 3.15 P.M. | 66 | 36 | 77.05 |
| .0591 | 1.32 P.M. | 70 | 33 | 91.04 |
| .0633 | 12.44 P.M. | 75 | 27 | 56.05 |
| Average | | | | 72.69% |

It will be noted that above 40% relative humidity the kills are quite consistent. Below 40% relative humidity the kills are low with two exceptions. An examination of these two exceptions reveals the fact that on these two days the relative humidity had come to its low in a gradual slope and soon rose again. In the other four cases the relative humidity had reached 40% by 7 A. M. and had remained below 40% for at least 12 hours during the day.

Another indication of the effect of low relative humidity was obtained by two fumigations of lemons from Fullerton.

| Relative humidity preceding fumigation | Temp. | Rel. Hum. | Kill |
|---|---|---|---|
| Below 40% for 1 hour | 76° | 38% | 98.05% ± .32 |
| Below 40% for 2½ hours | 76° | 34% | 93.28% ± .52 |

In another experiment lemons from Fullerton were kept for eight hours in containers where the relative humidity was controlled by pass-

ing the incoming air through sulphuric solutions or over sulphuric acid and calcium chloride. These lemons were then fumigated for 45 minutes in the metal box at a temperature of 62° and a relative humidity of 66.5% at 6:37 P. M. Following the fumigation, these lemons were returned to the containers with controlled humidity for a period of 14 hours.

TABLE 16. EFFECT OF RELATIVE HUMIDITY BEFORE AND AFTER THE FUMIGATION

| Preceding fumigation | After fumigation | Concentration per cent by volume | Kill |
|---|---|---|---|
| Rel. Hum. 73%–78% | Rel. Hum. 73%–80% | .0666 | 98.36%±.15 |
| " 73%–78% | " 34%–38% | .0666 | 98.66%±.14 |
| " 28%–35% | " 73%–80% | .0666 | 96.80%±.23 |
| " 28%–35% | " 34%–38% | .0666 | 95.72%±.30 |

Bearing on this same point, two fumigations on different nights in the same orchard at the same temperature but different relative humidities gave unequal kills.

| | | | |
|---|---|---|---|
| 5 P. M. | 56° F. | 60% Rel. Hum. | 98.27% |
| 7 P. M. | 56° F. | 30% Rel. Hum. | 89.30% |

These various tests indicate that both temperature and relative humidity are factors determining the success of the fumigation. The exact extent of the influence of each factor is not clearly defined.

EFFECT OF TEMPERATURE BEFORE AND AFTER THE FUMIGATION.—A set of lemons was placed in an ice box, a second set was hung by wires in the bright sunshine, a third set was placed in the shade in a screen room and a fourth set was placed in a room heated to 95° F. The lemons were from Corona, representing "resistant" red scale and from La Canada representing "non-resistant" red scale. Lemons from each source were fumigated together and then divided into sets placed under different conditions. Table 17 The cool chamber ran at 45° F. during the day and lower at night. The screen room reached a maximum temperature of 83° at 12:30 P. M., 78° at 4 P. M. and 59° at 7 P. M. 54° at 9 P. M. and a minimum of 51° during the night.

It appears that the high day temperature and low relative humidity had the greatest influence upon the kill but there are indications that cold following the fumigation will reduce the kill. One point should be mentioned, namely, that in bringing the cold lemons from the 8:51 P. M., fumigation into the warm room there was some condensation of moisture upon them. This moisture should have quickly evaporated since the relative humidity in the room was 41%.

TABLE 17. INFLUENCE OF TEMPERATURE CONDITIONS BEFORE AND AFTER FUMIGATION

| Conditions | Conditions preceding fumigation | Conditions after fumigation | Kill resistant | Kill non-resistant |
|---|---|---|---|---|
| Temp. 64.5°F.<br>Rel. Hum. 38.5%<br>Lemon temp. 49°<br>Concentration .0660<br>Time 9.18 A.M. | Cool chamber 45° | Cool chamber<br>Screen room<br>Sun | 84.15%±1.36<br>91.35%± .98<br>91.62%±1.0 | 95.68%±.69<br>98.77%±.31<br>98.47%±.42 |
| Temp. 68.5°F.<br>Rel. Hum. 36.5%<br>Lemon temp. 78.8–75°<br>Concentration .0592<br>Time 10.23 A.M. | In sun | Cool chamber<br>Screen room<br>Sun | 67.30%±1.45<br>74.76%+1.45<br>74.27%±1.50 | 98.62%±.35<br>98.65%±.29<br>99.33%±.23 |
| Temp. 75°F.<br>Rel. Hum. 27%<br>Lemon temp. 77°<br>Concentration .0633<br>Time 12.44 P.M. | In screen room<br>Shade | Cool chamber<br>Screen room<br>Sun | 62.45%±1.53<br>56.05%±1.66<br>71.71%±1.34 | 97.61%±.38<br>99.45%±.21<br>97.31%±.44 |
| Temp. 61°F.<br>Rel. Hum. 45%<br>Lemon temp. 91.4°<br>Concentration .0684<br>Time 7.48 P.M. | In heated room 95°F. | Cool chamber<br>Screen room<br>Heated room | 85.03%±1.24<br>80.05%±1.20<br>96.99%± .55 | 99.33%±.18<br>99.88%±.08<br>99.82%±.12 |
| Temp. 58°<br>Rel. Hum. 53.8%<br>Lemon Temp. 61.5°<br>Concentration .0608<br>Time 8.51 P.M. | In screen room | Cool<br>Screen room<br>Heated room | 90.55%± .89<br>90.98%± .86<br>98.01%± .44 | 100.00%<br>99.67%±.15<br>99.70%±.14 |

One field experiment indicates the effect of low temperature following a fumigation.

| | | | | | |
|---|---|---|---|---|---|
| Feb. 21, 1933 | 9 P. M. | 49° F. | 74% Rel. Hum. | | 92.08% Kill |
| Feb. 9, 1933 | 5 P. M. | 52° F. | 75% | " " | 75.68% Kill |

The conditions of the experiment were nearly the same on both dates, but on Feb. 21, the temperature did not fall below 48° all night, whereas on the 9th, the temperature fell rapidly reaching a low of 38°F. during the night. From these observations it would appear that temperature and humidity conditions preceding fumigation and temperature conditions after the fumigation had a bearing upon the kill.

COMPARISON OF "RESISTANT" AND "NON-RESISTANT" RED SCALE.—The real difference between the "resistant" and "non-resistant" red scale is brought out by the different kills obtained under different conditions and treatments as shown in Table 18. The concentrations range from .0591 to .0684 for 45 minutes exposure. This gives a time x concentration constant of 2.65 to 3.08 whereas the normal constant used in

fumigation is 3.41 to 3.95. With the "resistant" strain the kill may fall very low under unfavorable conditions such as high temperature, low relative humidity, pre-exposure to low concentrations, exposure to low relative humidity, preceding the fumigation or low temperatures following the fumigation. Under the same conditions, the "non-resistant" red scale reacts but slightly. Under favorable conditions, the kills of "resistant" and "non-resistant" scale may show no significant difference even with this low concentration.

TABLE 18. THE REACTION OF "RESISTANT" AND "NON-RESISTANT" RED SCALE TO DIFFERENT ENVIRONMENTAL CONDITIONS

| Conc. % by vol. | Time | Temp. | Rel. Hum. | Prefumigation treatment | Post-fumigation treatment | "Resistant" | "Non-resistant" |
|---|---|---|---|---|---|---|---|
| .0633 | 12.44 P.M. | 75° | 27% | Normal | Normal | 56.05%±1.66 | 99.45%±.21 |
| .0591 | 1.32 P.M. | 70 | 33 | Prefumigated | Normal | 60.45%±1.75 | 98.31%±.04 |
| .0591 | 1.32 P.M. | 70 | 33 | Not prefumigated | Normal | 91.04%± .87 | 99.18%±.28 |
| .0592 | 10.23 A.M. | 68.5 | 36.5 | Sun | Cool box 45° | 67.30%±1.45 | 98.62%±.35 |
| .0592 | 10.23 A.M. | 68.5 | 36.5 | Sun | Sun | 74.27%±1.50 | 99.33%±.23 |
| .0608 | 8.51 P.M. | 58 | 53.8 | Cool scrn. room | Cool scrn. room | 90.98%± .86 | 99.67%±.15 |
| .0608 | 8.51 P.M. | 58 | 53.8 | Cool scrn. room | Heated room | 98.00%± .44 | 99.70%±.14 |
| .0598 | 9.35 P.M. | 55 | 43 | Exposed to low Rel. Hum. | Normal | 88.00%±1.13 | 100.00% |
| .0598 | 9.35 P.M. | 55 | 43 | Normal | Normal | 95.69%±.65 | 100.00% |

Brinley and Baker (1) have shown with aphids and thrips that the kill resulting from treatment with hydrocyanic acid increased with temperature. Metabolic processes increase with an increase in temperature and since hydrocyanic acid affects the metabolic processes one would expect an increase in susceptibility with an increase in temperature. The data presented indicate the reverse to be the situation, namely, that higher kills are more frequently the result of fumigations at lower temperatures.

Moore (8) working with tender greenhouse plants found that plant injury may be prevented by fumigations at high temperatures and low relative humidities. High temperatures and low relative humidities reduce the absorption of the gas by the cuticle of the plants, whereas low temperatures and high relative humidities favor the absorption. A moist object will absorb more hydrocyanic acid than a dry object.

While chemical effects are increased by an increase in temperature, absorption and adsorption are increased by a lowering of the temperature.

With the data accumulated to date, it would appear that the difficulty of killing the "resistant" red scale was due to the difficulty of reaching the insect through its scale rather than to any distinct immunity of the insect itself to hydrocyanic acid. Under conditions favorable to the absorption or adsorption of hydrocyanic acid, the "resistant" and "non-resistant" red scale may be killed equally well but under conditions unfavorable to absorption but favorable to the action of hydrocyanic acid on the tissues of the insect, the kill of "resistant" red scale falls off whereas the kill of "non-resistant" red scale is reduced little, if any.

Assuming that in certain areas due to climatic conditions, the red scale secreted a larger quantity of wax than those in other areas, thus developing a covering more difficult to penetrate, we would have "resistant" and "non-resistant" scale insects.

SUMMARY.—The data presented should only be considered as a start of the problem.

The density of the red scale population upon a lemon has no striking influence upon the kill obtained.

The proportion of resistant stages of the red scale does not determine the effectiveness of the fumigation but probably determines which insects will survive in an unsuccessful fumigation.

The type of concentration curve has no decided influence upon the kill providing there is a good distribution of gas.

A low concentration built up and maintained and a quick high concentration rapidly leaking away gave similar results.

Under unfavorable conditions, satisfactory kills cannot be obtained by merely raising the concentration or increasing the time of exposure.

High temperature and low relative humidity favor a poor kill of "resistant" red scale.

In many cases, the insects are more difficult to kill where the temperature of the lemon is higher than that of the air.

Very low temperatures shortly following the fumigation will tend to reduce the kill.

Exposure of the insects to low concentrations of hydrocyanic acid before the fumigation may materially reduce the kill, have no influence upon it or actually increase the kill.

Under unfavorable conditions, the kill of "resistant" red scale is decidedly reduced whereas the kill of "non-resistant" red scale is influenced but slightly. Under favorable conditions, there is no significant differ-

ence between the kills of "resistant" and "non-resistant" red scale.

The main difference between "resistant" and "non-resistant" red scale is the influence, upon the results of a fumigation, of certain environmental conditions.

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# THE MECHANISM OF ABSORPTION OF SODIUM FLUORIDE BY ROACHES

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Contribution No. 157 from Department of Entomology, University of Illinois.

ABSTRACT

A technique is described whereby individual roaches (*Periplaneta americana*, *Blatta orientalis*) are straitjacketed and the fluoride applied to various parts of the body. The data so obtained is supplemented by dipping tests. The evidence all indicates that sodium fluoride can be absorbed directly through the body integument of the insect, especially through the membranous areas of the body wall, such as the junction of the head and thorax and also the region of the coxae. The large area of absorption necessary to take up enough fluoride to kill the insect would indicate that in actual practice the roach must absorb some of the toxic material by licking it off the body appendages.

Few insecticides have so admirably filled a need as has sodium fluoride when used against roaches. For many years, it has been the standard remedy for household as well as commercial use. Its cheapness, ease of application, and effectiveness have led to its being given first place by many writers on their list of recommended materials for killing roaches. If scattered about where the roaches are sure to run, it may be depended upon to kill many of the pests; and by its recurrent use premises can be kept reasonably free from roaches.

The exact mechanism whereby the chemical kills the insect has not been carefully studied, but evidence from various sources indicates that it adheres to the antennae and tarsi when the roach runs over it and is then licked off in the cleaning process to which the insect subjects these parts. Some evidence, notably that of Shafer[1] indicates that the fluoride can be directly absorbed through the body integument after partially dissolving in the body exudations. With these facts in mind the following experimental work was performed to determine if possible the exact mechanism of absorption.

METHOD.—In all of the tests, only adult specimens of *Periplaneta americana* and *Blatta orientalis* were used.

In order to be able to hold the roaches so that they would not lick any part of the body or otherwise remove the applied materials, it became necessary to devise a type of individual cage, which is herein referred to as a straitjacket. This consisted of a piece of bronze fly screen, 1 inch by 3 inches, folded back on itself crosswise. A small piece of wood, ½-inch wide and ⅛-inch thick, was then inserted between the folded edges and the wire screen bent around it. This molded the strait-

[1]Shafer. Geo. D. 1915. Mich Tech. Bul. 15 Part III.

jacket to a size and shape well suited to hold a roach without injuring it or permitting it to move in any direction. The two sides of the straitjacket were held together by a rubber band. A pair of crucible tongs with thin blades were used to handle the insects. If they were caught across the thorax by this instrument, they could be transferred to the straitjacket and a rubber band slipped into place with a minimum of effort and no injury to the roach. In some cases the fluoride was applied to the roaches while held in the crucible tongs and they were then placed in the straitjackets, and in other cases they were first jacketed and then fluoride later applied. Several control tests with both the Americana and the Orientalis roaches showed that roaches of both species could be held in the straitjackets for at least two days without injury, and if removed to jars by that time might be expected to live for several days longer.

Two samples of fluoride were used; one an ordinary crystaline sodium fluoride consisting of particles varying from 2 microns to 800 microns in diameter, and a second which was the same product ground in a ball mill and air floated so that all the particles were from 1 to 5 microns in size.

EXPERIMENTAL.—In the first test, .5 grams of the very fine sodium fluoride was distributed as evenly as possible over the bottom of a 10-inch round glass container. Five specimens of *Periplaneta americana* were put into this jar one at a time and caused to run about over the fluoride for 30 seconds. Each was then placed in a separate small fruit jar and observed for twenty hours without any food being given. At the end of twelve hours, three roaches were dead, one nearly dead, and one in fair condition but showing injury. In twenty hours, all were dead.

A similar experiment was conducted simultaneously, but using the ordinary sodium fluoride. In twelve hours, two roaches were nearly dead and three showed only a little injury. In twenty hours, two were dead, two nearly dead, and one but little injured.

In both tests, the roaches were examined carefully at the time they were removed from the large jar containing fluoride to the small observation jars. It was found that the finely ground fluoride had adhered much better than the coarser material and that both powders were adhering to the following parts: the palpi, the tarsi of all six legs, the tibia of the metathoracic legs, and in large amount to the last three abdominal segments on the ventral surface. The antennae held no noticeable amount of the fluoride, probably due to the fact that the roaches were running excitedly and so held the antennae up out of contact with the floor of the jar.

Two similar experiments were run as follows: In one 3-inch fruit jar was placed .1 gram of the very fine powdered fluoride and in another, .1 gram of the coarser material. Five *Blatta orientalis* were placed in each jar and allowed to remain there. In the case of the coarse powder, the insects seemed unaffected in twenty hours; and only one was dead and one sick in forty-four hours. In the case of the very fine powder, two of the five were very sick in twenty hours, and all were dead in forty-four hours.

The following experiments were conducted to determine the relative importance of the above-mentioned points of adhesion in the actual poisoning of the roach: Two American and three Oriental roaches had very fine sodium fluoride applied to the palps by means of a camel's hair brush. They were placed in a fruit jar and observed for forty-eight hours, at which time they were all seemingly normal, and the experiment was discontinued. Five Americana roaches had very fine sodium fluoride applied to all of their tarsi and were then placed in a jar for observation. In twenty-four hours, one was dead and four seemed unaffected. In thirty-two hours, two were dead, two nearly dead, and one seemingly uninjured.

Similarly five Oriental roaches were treated with very fine sodium fluoride on the metatarsi only. After seventy-two hours, they were all active and the experiment was discontinued. In another test, the coarse sodium fluoride was brushed on the antennae of five Oriental roaches, and they were placed in a fruit jar. Within a few minutes, all the roaches had drawn their antennae through their mouthparts in the familiar act of washing. At the end of twenty-four hours, they were all active, and in forty-four hours only one was seemingly sick. This one died in fifty-six hours, but the other four were active at the end of eighty hours.

The above experiment was repeated with the five roaches placed in individual jars. All were active at the end of fifty-six hours. A similar test with the very fine powder gave a similar result.

From the above experiments one concludes that the roach must lick a considerable area of his appendages before enough fluoride is taken through the mouth to produce death in a reasonably short time. These tests throw no light on the question of the absorption of the fluoride directly through the body integument. It seems extremely unlikely that there would be absorption through the tibia, so a study of the absorption through the antennae and the last segments of the abdomen was made as follows:

Five Americana roaches were placed in straitjackets with the head free and then hung upside down just over a saturated solution of sodium fluoride so that the antennae dipped into the solution but no other part of the insect touched it. They were left in this position for twelve hours and were all alive and uninjured at that time.

At the same time, two Americana roaches were jacketed as above and a paste of the very fine sodium fluoride with a little water was placed on their antennae. In twelve hours, they were released and found uninjured. To determine if the roaches readily swallowed a solution of sodium fluoride, a saturated solution was made and two American roaches were jacketed and hung for five minutes in the solution with the head and mouthparts alone submerged. When released from the jackets twelve hours later, they were quite active.

To determine whether or not absorption through the last abdominal segments was important, five Oriental roaches were jacketed with the last three abdominal segments free. These segments were then dipped in very fine fluoride dust and the insects left in the jackets for twelve hours. They were very active when released, though it was noticed that the powder adhered in large amounts around the anal opening.

These tests indicate that no one of the parts of the insect which normally come into contact with the fluoride are very important as places for the absorption of the fluoride.

The following tests were then run to determine if any other area of the body was capable of taking up enough fluoride to produce death: Five Oriental roaches were placed in jackets after a small amount of very fine fluoride had been placed behind both metacoxae. Twelve hours later, one roach was dead, two nearly dead, and two fairly lively except that their metathoracic legs were paralyzed.

In a similar experiment using five American roaches, the sodium fluoride was dusted between all the thoracic legs. In twenty-four hours, all were dead. The chitin is quite thin and flexible around the point of junction of the legs and thoracic segments and this probably accounts for the effectiveness of fluoride placed on this area. A similar but smaller area exists between the head and thorax. Accordingly, five Oriental roaches were jacketed and very fine sodium fluoride was dusted on the dorsal side of the junction of the head and thorax, while the insect was held upside down to prevent any powder from falling down to the mouthparts. In twelve hours, three were dead, one nearly dead, and one fairly active. A similar experiment was performed, using American roaches and the coarser powder. When released twelve hours later, four roaches were quite sick and two, active. They were placed in separate

jars for further observation, and in another twelve hours two were dead and the other four, quite active. Twelve hours later the same condition prevailed, and the observations were discontinued. From these tests, it can be seen that the fluoride can be absorbed through the thinly chitinized areas in sufficient amount to cause death, and that the fine powder is more effective than the coarser material.

In the following tests, the question of absorption through the more heavily chitinized areas was considered.

Ten Oriental roaches were jacketed and the entire ventral side of the abdomen pressed lightly into very finely powdered fluorine. The insects were then set to one side for eighteen hours. At the end of this time, four were dead, three nearly dead, and three only slightly injured. It was noted that the degree of injury was nicely proportional to the amount of fluoride adhering to the abdomen. There was a large variation in the amount of material adhering. Care was taken not to allow any of the powder to get up to the lateral edge of the abdomen and so possibly into the spiracles. Following this, three Americana and two Oriental roaches were placed in straitjackets, and very fine sodium fluoride was dusted liberally over the ventral side of the abdomen while the insects were on their backs. After sixteen hours, one Americana and one Oriental were dead and two Americana and one Oriental, alive. After twenty-four hours, four were dead and one, alive. Simultaneously, ten roaches were dusted over the entire dorsal side of the abdomen with very finely powdered fluoride, using a camel's hair brush and being particularly careful to apply it liberally to the abdominal spiracles. The insects were placed in separate jars and not placed in jackets. Eighteen hours later, nine were apparently unaffected and one, slightly affected. From the above tests, it can be seen that the spiracles are relatively unimportant as a point of entry for fluoride dusts, even though the dust is very finely powdered. The ventral side of the abdomen is seen to be much more permeable than the dorsal.

A series of tests were then run in which the roaches were dipped in saturated sodium fluoride and the solution allowed to dry on the insects, thus depositing the fluoride on the body integument. In the first test, five roaches, two Oriental and three American, were placed in straitjackets and the abdomen dipped for one minute in saturated sodium fluoride. Sixteen hours later, one Oriental was dead, one nearly dead, two Americana dead, and one in fair condition. Apparently enough fluoride had been absorbed to produce death by this method, but it does not show whether the absorption was through the spiracles or through the chitin of the body integument, or through both.

To determine this, a test was run as follows: Five Oriental roaches were jacketed and the abdomen dipped for one minute in saturated sodium fluoride. The insects were then rinsed quickly in cold water to remove the fluoride solution adhering to the body integument. Twenty-four hours later they were released from the jackets and found to be uninjured.

A comparison of these three tests indicates that the absorption is largely through the body integument, and not through the spiracles, because the solution taken up by the spiracles would not be removed by a quick rinsing in water.

Since a previous test had shown that roaches hung with the head submerged for five minutes did not swallow enough fluoride solution to cause death, it was felt that the entire insect might be safely dipped in the solution. Accordingly, eleven Oriental roaches were placed in a fruit jar and a saturated solution of sodium fluoride was poured over them. They were allowed to swim in the solution for thirty seconds while the jar was gently rotated to assure frequent submersion. The solution was then drained off and the roaches allowed to crawl into a clean jar. In sixteen hours, all were dead.

This experiment was duplicated save that after draining off the fluoride solution the insects were quickly rinsed in water. In sixteen hours, one was dead and the other ten, quite active. This last experiment was repeated, and the results were identical in that one roach was dead and ten, apparently quite uninjured in sixteen hours.

In order that ample time might be allowed for penetration of the trachea by the solution, the above tests were repeated as follows: Fourteen Oriental roaches were caused to swim in saturated sodium fluoride for thirty seconds and then rinsed. After twelve hours, one was dead and thirteen, apparently uninjured.

Ten Oriental roaches were then placed in the same solution for two minutes, drained, and rinsed. In twelve hours two were dead and eight, unaffected. Then ten Orientals were kept in water for five minutes, drained, and rinsed. After twelve hours, all were apparently uninjured.

The above tests indicate very strongly that the fluoride solution kills the roaches by actual absorption through the body integument and not by penetration of the trachea. One possibility, however, is that the solution when it dries on the insect is thereby drawn into the trachea. To eliminate this possibility, the following tests were run: Five Oriental roaches were dipped twenty seconds in saturated sodium fluoride and then removed to a clean jar without rinsing. In fifteen hours, they were

all dead. Five Oriental roaches were then dipped for twenty seconds in a similar solution and quickly dried in a warm air blast. The drying process required about four minutes. In fifteen hours, they were all dead. Finally, five Oriental roaches were dipped in a similar solution, dried in the air blast, rinsed in water, and again dried in the air blast. In fifteen hours, they were apparently normal and active.

These experiments would indicate that the trachea are not a factor in the absorption of a saturated sodium fluoride solution. There yet remains the possibility that the sodium fluoride acts merely as a dessicating agent and is not absorbed. The following experiments were conducted to determine this point. Twenty Oriental roaches were dipped thirty seconds in saturated sodium fluoride and allowed to dry without rinsing. In fifteen hours, all were dead. Ten Oriental roaches were treated as above, except that 5% sodium chloride was used in place of the saturated (about 4.5%) solution of sodium fluoride. In fifteen hours, two were dead and eight quite lively. Ten Oriental roaches were dipped thirty seconds in saturated sodium fluoride and then rinsed in water before setting aside. In fifteen hours, two were dead and eight entirely unaffected. Ten similar roaches were similarly treated, but 5% sodium chloride was used. In fifteen hours, three were dead and seven entirely unaffected. It should be noted at this point that in these above four tests the roaches were some that had been in the laboratory for two days and were not as vigorous, probably, as the roaches used in all the other tests of these experiments. Consequently, the death of two or three roaches in ten may be looked upon as largely accidental. The results of these tests suggest that the lethal action of the sodium fluoride is not shared by sodium chloride and so must be attributed to the action of the fluoride ion.

Finally, a previous experiment was repeated to determine if enough fluoride could be absorbed through the abdomen alone to insure early death.

Five Orientals were placed in straitjackets and the abdomen dipped in saturated sodium fluoride plus blood albumen. They were then dried in a warm air blast and set aside. In fifteen hours, three were nearly dead and two but little if at all injured. Five Oriental roaches, similarly treated but rinsed and again dried, were all in good condition after fifteen hours.

The first of these two tests shows that enough fluoride can probably be absorbed through the abdomen alone to insure death, since three of the roaches out of five probably would have died in another ten hours. Since even five minutes of partial submersion in saturated sodium

fluoride did not cause death if the excess were rinsed off, it was thought that the surface tension of the solution was probably too high to permit penetration of the spiracles. Accordingly, roaches of both the American and Oriental species were dipped for thirty seconds in ½% solutions of a sulfonated fish oil in water. This solution apparently drowned the roaches as they were quiet when removed from the solution and never recovered activity.

CONCLUSION.—Sodium fluoride can be absorbed in lethal amounts directly through the body integument of the American and Oriental roaches, especially in the areas of the body where the chitin is thin and flexible. The coefficient of absorption is apparently rather low; and, since the fluoride dust as ordinarily used does not come in contact with the most effective areas, it is not likely that direct absorption is of very great practical importance in roach control. Neither an extremely finely powdered sodium fluoride dust nor a saturated water solution was taken up by the tracheal system in sufficient quantity to cause death. Enough fluoride is not swallowed by the roach in washing the antennae to cause death, but if the tarsi are all covered with fluoride enough may be taken in by way of the mouth. Fluoride accumulating on the palps is apparently not sufficient to cause death. Very finely powdered sodium fluoride is much more efficiently absorbed than is a coarser product.

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## COMMON NAMES OF INSECTS APPROVED FOR GENERAL USE BY AMERICAN ECONOMIC ENTOMOLOGISTS

First Supplement to List Appearing in Volume 24, Pages 1273–1310

A list of 70 common names was submitted to the active members of the Association for consideration, with the understanding that a name be considered adopted when less than 20 per cent of the votes cast was in opposition. Of this number 26 received the necessary votes for adoption. This list is given below with the addition of one change from a name previously adopted and one additional name for *Diabrotica duodecimpunctata* Fab.

### INSECTS LISTED BY SCIENTIFIC NAMES

| | |
|---|---|
| Adelphocorus rapidus Say | Rapid plant bug |
| Anastrepha ludens Loew | Mexican fruit fly* |
| Aspidiotus hederae Vallot | Oleander scale |
| Brachyrhinus ovatus L. | Strawberry root weevil |
| Coccus pseudomagnoliarum Kuw. | Citricola scale |
| Coleophora pruniella Clem | Cherry case bearer |
| Diabrotica duodecimpunctata Fab | Spotted cucumber beetle<br>Southern corn root worm |
| Euscepes batatae Waterh | West Indian sweetpotato weevil |

*Changed from Orange maggot.

| | |
|---|---|
| Haltica canadensis Gent | Prairie flea beetle |
| Lepidosaphes ficus Sign | Fig scale |
| Ludius inflatus Say | Dry land wireworm |
| Ludius pruininus noxius Hyslop | Great basin wireworm |
| Megalopyge opercularis S. & A | Puss caterpillar |
| Mordwilkoja vagabunda Walsh | Poplar vagabond aphid |
| Nodonota puncticollis Say | Rose leaf beetle |
| Panchlora cubensis Sauss | Cuban cockroach |
| Passalus cornutus Fab | Horned passalus |
| Pediculoides ventricosus Newp | Straw itch mite |
| Pheletes californicus Mann | Sugar beet wireworm |
| Prionus californicus Mots | California prionus |
| Prociphilus imbricator Fitch | Beech blight aphid |
| Rhabdocnemis obscura Bdv | New Guinea sugarcane weevil |
| Rhizoecus terrestris News | Ground mealybug |
| Scutigerella immaculata Newp | Garden centipede |
| Solenopsis molesta Say | Thief ant |
| Taeniothrips gladioli M. & S | Gladiolus thrips |
| Tarsonemus latus Bks | Broad mite |
| Typhlocyba pomaria McAtee | White apple leafhopper |

### Insects Listed by Common Names

| | |
|---|---|
| Beech blight aphid | Prociphilus imbricator Fitch |
| Broad mite | Tarsonemus latus Bks. |
| California prionus | Prionus californicus Mots. |
| Cherry case bearer | Coleophora pruniella Clem. |
| Citricola scale | Coccus pseudomagnoliarum Kuw. |
| Cuban cockroach | Panchlora cubensis Sauss. |
| Dry land wireworm | Ludius inflatus Say |
| Fig scale | Lepidosaphes ficus Sign. |
| Garden centipede | Scutigerella immaculata Newp. |
| Gladiolus thrips | Taeniothrips gladioli M. & S. |
| Great Basin wireworm | Ludius pruininus noxius Hyslop |
| Ground mealybug | Rhizoecus terrestris Newst. |
| Horned passalus | Passalus cornutus Fab. |
| Mexican fruit fly | Anastrepha ludens Loew |
| New Guinea sugarcane weevil | Rhabdocnemis obscura Bdv. |
| Oleander scale | Aspidiotus hederae Vallot |
| Poplar vagabond aphid | Mordwilkoja vagabunda Walsh |
| Prairie flea beetle | Haltica canadensis Gent. |
| Puss caterpillar | Megalopyge opercularis S. & A. |
| Rapid plant bug | Adelphocorus rapidus Say |
| Rose leaf beetle | Nodonota puncticollis Say |
| Southern corn root worm | Diabrotica duodecimpunctata Fab. |
| Strawberry root weevil | Brachyrhinus ovatus L. |
| Straw itch mite | Pediculoides ventricosus Newp. |
| Sugar beet wireworm | Pheletes californicus Mann. |
| Thief ant | Solenopsis molesta Say |
| West Indian sweetpotato weevil | Euscepes batatae Waterh. |
| White apple leafhopper | Typhlocyba pomaria McAtee. |

# Scientific Notes

**Pyrethrum Solutions for Determining Insect Infestations on Golf Greens.** During the course of experimental work on webworms infesting golf greens in the summer of 1933, it was observed that some of the caterpillars on golf greens reported injured by sod webworms were second instar cutworms. A survey of several injured greens revealed that around 50 per cent of the cases had no sod webworms. The survey was made by wetting down unit areas of the greens with a solution ((approximately .001% pyrethrins) of pyrethrum, which caused the insects secreted about the roots of the grass to come to the surface. All the cutworm infestations discovered in this way yielded to applications of poisoned bran bait, as proved by subsequent determination.

RAY HUTSON, *Section of Entomology, Michigan State College, East Lansing, Michigan.*

**Long-tailed Mealybug Abundant on Citrus.** The long-tailed mealybug, *Pseudococcus longispinus* Targ., heretofore considered primarily as a greenhouse pest and as an occasional pest on ornamentals, has appeared in large numbers on citrus in Rivera, Los Angeles County, California.

This species of mealybug has been known to occur on citrus in the Rivera district for a number of years, but this is the first time that it has become sufficiently abundant to require special attention. It has been estimated that approximately two hundred acres are involved in the infestation.

The Australian ladybird beetle, *Cryptolaemus montrousieri* Muls., which has been used with great success as a predator on all other species of mealybug in this district, does not readily take to the long-tailed variety, thus necessitating the use of other control measures.

Consequently, tests were made to determine the effect of regular field practice fumigation and spraying on this pest. It was found that the customary grove fumigation of cyanide using a 16 cc schedule, which could be used as a combination treatment for other scale pests, gave excellent results.

The long-tailed mealybug is the least injurious of any of the citrus-infesting species, and even in the most heavily-infested groves there has been as yet no damage other than the presence of sooty mold fungus upon the leaves.

DON. W. CLANCY, *Los Angeles County Insectary, Rivera, California.*

**The European Corn Borer in Egypt,** *Pyrausta nubilalis* Hbn. was first reported for Egypt by Herr A. Andres in his "Note sur un Nouveau Ravageur de Mais" published in the Bulletin of the Societé Entomologique d'Egypte in December, (1912), on some ears of corn purchased from a street vendor, probably in Alexandria, altho he fails to state definitely the location. He states, however,

> "Je ne dispose pas de suffisantes observations pour savoir si cette espèce se trouve assez répandue en Egypte pour causer des ravages importants."

Curiously enough, considering the unenviable notoriety which this insect has attained in other corn-growing countries—maize is one of the most important Egyptian cereal crops—when the writer came to Egypt a score of years after Andres' observation there was still insufficient evidence to base serious charges of damages by *Pyrausta*. In Storey's List of Egyptian Insects is recorded the capture of the species at Ma'adi,

a suburb of Cairo, and also as far south as Minia, in Upper Egypt, while specimens existed in the private collection of Mr. Alfieri, taken by him in Alexandria. In the collection of the Ministry of Agriculture at Cairo there are several specimens labeled "Feeding on Maize at Damietta (on the Mediterranean) in Aug. 1916. In 1925, F. C. Willcocks, in his monumental work on "The Insects and Related Pests of Egypt," reported:—

> "We have never received any inquiries concerning the European corn borer, and although I have kept a special look out for it at Gizeh and elsewhere, I have have never been able to fine a trace of it."

Intrigued by the lack of any record of actual damage in Egypt by this normally voracious insect and by its apparent failure to spread widely despite its long established residence in the country, the present writer has for the past year kept a close watch on corn from Giza south to Assouan, with the same results recorded by Willcocks. In July last Dr. H. Priesner, the Entomologist of the Ministry of Agriculture, mentioned that he had received a suspicious looking larva from corn near Alexandria and when bred out this proved to be *P. nubilalis*. The following month, Dr. I. Fahmy, one of Dr. Priesner's assistants, made the first report of any appreciable infestation, about 5%, on some maize near Damietta on the upper portions of the plants

ARTHUR H. ROSENFELD, *Ministry of Agriculture, Giza, Egypt.*

**Otiorhynchids Oviposit Between Paper.** The oviposition habits of the common, large, leaf-eating weevil of the West Indies, *Diaprepes abbreviatus* L., have long been known: that eggs are laid between two leaves, or between the split tips of a single cane leaf. A few years ago, Dr. Herbert Osborn Jr. noted that, in captivity, the beetles preferred paper to leaves between which to oviposit. The writer has found that this preference is shown not only in captivity, but also in the field.

In a small citrus nursery at Isabela, P. R., in which each seedling tree was tied to a slender stake, he affixed strips of paper to the tops of dozen or more of these stakes with a clip, the strips being eight or ten inches long and two or three inches wide, wrapped at their middle around the stake so that the two long loose ends were opposite each other. To a very surprising extent, these paper flags were chosen by the female beetles for oviposition, the theoretical rate of preference being overwhelmingly in favor of the paper, if one considers the available amount of leaf surface as compared with that of the dozen paper flags on the stakes. The preference was shown not only by the larger *Diaprepes* weevils, but also by the smaller *Lachnopus curvipes* F., which at Isabela were feeding on and ovipositing between citrus leaves. Within the last few days, large numbers of the small green weevil, *Prepodes* (*Exophthalmodes*) *roseipes* Chev., have been held in captivity, and it is found that the female of this species also always chooses paper in preference to leaves between which to lay her eggs. Indeed, the preference is so general in all the species observed that it may occur in similar beetles found elsewhere than in the West Indies.

The economic application of the preference of Otiorhynchid beetles for oviposition in paper is possibly not as obvious and immediate as the more generally practised methods of control, but is none the less certain. An exceptionally effective adhesive is required to stick together two shiny citrus leaves so that they will remain in close adherence until after the hatching of the enclosed eggs. Such the beetles possess. It is so effective indeed that the emergence of the young grubs from hatching egg-masses is often delayed for several hours, or days, until a thin place in the ring of it

laid around the egg-mass by the female can be found. When used for ovipositing between two sheets of paper, it is so much more effective than is necessary that the just-hatched grubs can not emerge, but imprisoned within its celophane-like ring, dry up and die. In nature, they never attempt to burrow thru the leaf to escape from the egg-cluster, and under the artificial conditions of egg-clusters between paper, they do not attempt to burrow thru the paper. Thus, once the paper flags are in place, they form an automatic trap for the eggs of the beetles, not needing to be renewed until the paper itself becomes soft and weathered. In the tropics, the traps remain effective for at least three months, using thin, tough wrapping paper.

GEORGE N. WOLCOTT, *Entomologist, Insular Experiment Station, Rio Piedras, P. R.*

**Notes on Potato Insects in Iowa.** While making a survey of potato insects, the author on June 12, 1933 collected considerable numbers of small greenish colored caterpillars which were mining the potato leaves and quite frequently entered the petioles. Since this type of injury as well as the general appearance of the larvae was known to be characteristic of the potato tuber moth (*Phthorimoea operculella* Zeller), it was provisionally considered as such. Later both adult and larval specimens were determined by Dr. Carl J. Heinrich of Washington as *P. operculella* Zeller. Apparently this represents the first record of the potato tuber moth in Iowa. The wide distribution of this pest in Iowa as evidenced by collecting records made during the current season indicates that it has been established in the state for a few years. Specimens have been taken from various points in the entire eastern half of the state. In a few instances growers have reported the occurrence of caterpillars in potatoes in storage. Considerable numbers of the larvae were found to be parasitized by an ichneumonid parasite.

The potato stalk borer (*Trichobaris trinotata* Say) caused severe damage to potatoes in some fields during the summer of 1933, ranking next to the potato leafhopper as an important potato pest. This insect is present each year but serious outbreaks are of a sporadic nature. According to reports published by Dr. C. P. Gillette widespread damage occurred in Iowa in 1890 and again in 1892. Webster reported that *T. trinotata* occurred quite commonly in the state in 1912–13. In certain fields at both Ames and Pleasant Valley, Iowa, where the degree of infestation was checked carefully this season (1933), more than seventy-five per cent of the plants were infested and approximately ten per cent of these gradually wilted and died in the early part of July.

Two species of mirids, *Chlamydatus associatus* (Uhler) and *Campyloma verbasci* (Meyer), were present in large numbers on potato plants throughout the early part of the summer. According to present records they have not been previously associated with this host in Iowa. Their relationship to the potato plant and the damage resulting from their feeding activities and egg punctures have not been definitely established. All stages, including the eggs, of both species have been obtained in large numbers from the potato plant.

The false chinch bug has occurred in destructive numbers in many parts of Iowa during the last two years (1932–33) and occasionally has been observed to cause some injury by feeding on potato foliage. Such injury may be attributable to the fact that the natural host plants of the false chinch bug growing adjacent to potato fields were destroyed either by drought conditions or in the process of cultivation.

H. D. TATE, *Iowa State College, Ames, Iowa.*

**On the probable reason for the scarcity of the Southern corn stalk borer (*Diatraea crambidoides* Grote) in Southeastern Georgia.** In the coastal plain of eastern Georgia observation of cornfields during four seasons (1930 to 1933, inclusive) has shown that *Diatraea crambidoides* Grote, though present each year, has occurred in very small numbers, probably averaging not more than one larva to several thousand corn stalks. Being rare, the insect was of no economic importance during the period mentioned, and it seemed evident that an important factor was holding this injurious species in check.

In the light of investigation it appeared unlikely that a climatic factor was responsible for the scarcity of borers in the field. During 1931, beginning with one-half dozen larvae collected during the last week of May, the insect passed through three complete generations and a partial fourth, and larvae entered hibernation in largest numbers between the middle and the last of September.

The hibernating larvae within corn stalks were placed in soil hibernation cages during the last week of September. Within a few weeks every one of these larvae was devoured by a very common carnivorous ant determined by W. M. Mann as *Solenopsis xyloni* McCook. Many subsequent observations on occurrence and abundance of this ant, especially in cornfields of the coastal plain, indicated that in all probability it was the most important factor in limiting the abundance of *D. crambidoides*.

This species' habit of hibernating in the larval stage within the corn stalks during the long interval from the last of September, or earlier, to the last of the following April or early May subjects the insect during most of this period to attack by the ants, as these are active during much of the season mentioned. The ants continually search over the cornfields for insects they are able to destroy, and it seems probable from the observations made that they discover and devour most of the hibernating larvae of *D. crambidoides*, or so large a percentage of them that injurious populations of the insect are built up but slowly during a succeeding growing season.

GEORGE W. BARBER. *United States Department of Agriculture, Bureau of Entomology*

**Insects Attacking *Solanum sisymbriifolium* in eastern Georgia.** *Solanum sisymbriifolium* Lam. is a member of the family Solanaceae and was introduced from tropical America into the Southern States. It is peculiar entomologically in the unusual association of insects attacking it, which include a principal insect enemy of tobacco and the most important injurious insect of tomato and of potato. This plant is described in the floras as an annual, but in some instances, at least, it is a biennial. It grows from 2 to 4 feet high, bearing abundant fruits which turn red upon ripening. The plant is "armed all over with bright yellow prickles," including the upper and lower surfaces of the leaves and the husks of the fruit. The plant appears in March or April, depending upon whether it springs from roots or seeds, and it grows luxuriantly until October, during which period it is suitable as food for the insects mentioned below. Often grown as an ornamental for the sake of its showy fruit, it also has a limited distribution along roadsides and other waste places. The insects attacking it include the following:

*Leptinotarsa decemlineata* (Say). The Colorado Potato Beetle.—In eastern Georgia potatoes are grown early in the season, being harvested in June, and by July these plants have wholly disappeared from the field. For a few weeks the beetles are found feeding upon alternative and less favoured food plants, doing frequent damage at

this time to tomatoes and eggplants as well as feeding during July on a number of wild hosts, before disappearing for the year. However, eggs and larvae of this insect are seen on few of these plants, the injury, for the most part, being done by the adults. Nevertheless, during 1932, it was observed that this insect passed through a complete life cycle on *S. sisymbriifolium*, and this condition seemed to indicate that this plant was rather more suitable as food for this insect than many others on which it had been recorded.

*Heliothis virescens* (Fab.). The Tobacco Budworm.—Larvae of *H. virescens* are found attacking the tender leaves and unripe or ripe fruit of *S. sisymbriifolium* throughout the season. Frequently they strip the younger leaves and devour all the fruit on individual plants, as was the case in 1932; in 1933 they were generally less abundant. However, this plant is suitable as food for the larvae over a period of 5 or 6 months; and, since it has been found that a generation of the insect occupies about a month, from five to six successive generations may be passed on this plant in a year. Tobacco is harvested and generally disappears from the field during June in nearby areas, while *S. sisymbriifolium* is available as larval food from the time the adults first emerge from hibernation in the spring until the insect begins hibernation in the fall.

*Protoparce sexta* Johanssen. The Tomato Worm.—Tomatoes are usually transplanted into the field in April in this section and grow until the middle or the last of July, or occasionally until the middle of August. However, the larvae of the tomato worm are often found as commonly, or even more abundantly, on *S. sisymbriifolium* as on tomatoes throughout this period, as well as during the period after midsummer, when tomatoes are becoming less abundant, and until they disappear from the field. Often plants are entirely stripped of leaves by the larvae of this insect; and, as in the case of *H. virescens*, this wild host not only is a satisfactory host plant during periods when the cultivated hosts are wanting, but it provides an uninterrupted source of food from the time the insects emerge from hibernation until they begin hibernation again.

The long period occupied in growth by this plant, covering the whole of the growing season, permits *S. sisymbriifolium* to serve as a host to which the insects mentioned above may turn during seasons when their preferred cultivated food plants are wanting in the field, and on which, to a degree, their numbers may be saved from depletion because of lack of desirable food. This plant, therefore, occupies an important place in the economic agriculture of eastern Georgia by helping to maintain a stock of three important injurious insects.

GEO. W. BARBER, *U. S. Department of Agriculture, Bureau of Entomology, Savannah, Ga.*

**A Flotation method for determining abundance of Potato Flea Beetle Larvae.** It was important during investigations on the control of the potato flea beetle (*Epitrix cucumeris* Harris) to determine the number of larvae and pupae per hill of potatoes. The soil inhabiting forms of this insect are very delicate, soft-bodied and easily damaged by the ordinary methods of screening[1] and washing[2].

[1]Lane, M. C. 1928—A Soil Sifter for Subterranean Insect Investigations. Jour. Econ. Ent. Vol. 21—No. 6.

[2]Shirck, F. H. 1930—Soil Washing Device for Use in Wire Worm Investigations. Jour. Econ. Ent. Vol. 23—No. 6.

The method found most satisfactory was a system of flotation in which the larvae and pupae were floated out by agitating the soil from the potato hill with water. Shallow galvanized pans, 24 inches in diameter and 8 inches deep, were used as they gave an area large enough to reduce the thickness of the soil on the bottom to less than an inch. At first solutions of sodium chloride were tried but it was found that thorough agitation with water brought all of the forms to the surface. The settling process of several minutes eliminated clogging of the screens with mud when the liquid was poured off from the sample.

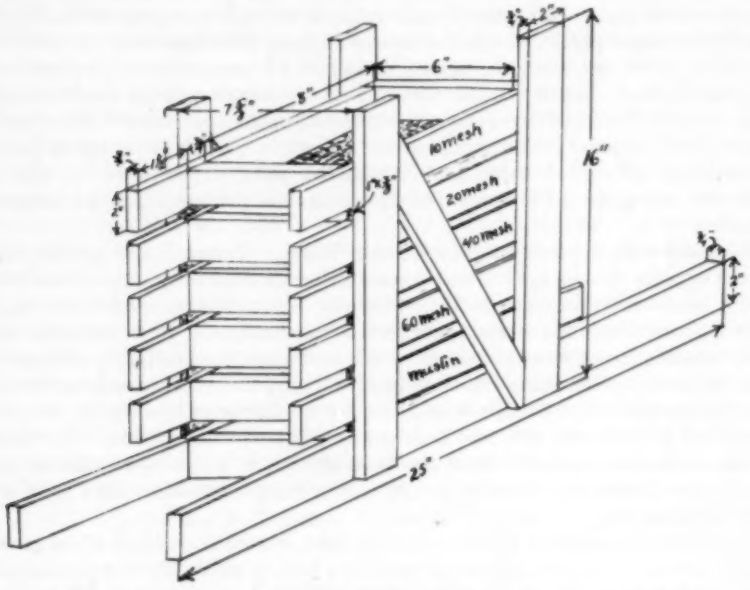


FIG. 110.—Drawing showing construction of screens used in collecting larval and pupal forms obtained by flotation.

The screens used in collecting the larvae were made from brass cloth. The largest mesh was the 10 to the inch mesh which removed all of the sticks and trash. This was followed by a 20, 40 and a 60 mesh screen. The pupae and some larvae were caught in the 20 mesh, but most of the larvae were taken in the 40 mesh screen. For a time a muslin filter was used to make sure that all the forms required were being taken in the screens. It was soon found that this stage was not necessary.

Each screen was mounted on a wooden frame. These frames were made from pine 2 inches wide and three-fourths inch thick. Their shape was rectangular, 6″ x 8″ with a 1.5″ projection on one end, to facilitate handling and withdrawing from the rack holding the screens. Each screen was a separate unit and could be withdrawn without disturbing the others. The drawing illustrates the arrangement and the construction of the screen frame and rack.

The rack holding the screen frames was made of 2″ x ¾″ material fastened together with screws. It consisted of 4 upright pieces 16″ high fastened to a base of 2 pieces 25″ long, sufficient to reach across a flotation pan. The uprights were placed

far enough apart to allow the screens to be inserted with ease, 7.6″ wide and 9.5″ long. The 1.5″ projection from each screen extended so that it could be easily grasped for removal. The slides for each screen were made from 1 by ⅜ inch material Each piece was 9.5″ long and a pair of them were firmly attached to the four uprights. The screen rested on the slides. The whole frame was strongly braced with two pieces fitted into the sides.

The liquid from the pans was poured through the screens. A gentle washing with a spray cleared away the mud and sediment. Each screen was removed to make the counts. It was found that a large rectangular white enamel pan, with clean water in the bottom, aided in counting and increased the efficiency of the method. The bottom of the screen was immersed in the shallow water and the larvae and pupae were readily identified.

This method has been used successfully in 1931 and '32, in determining the number of flea beetle larvae and pupae in the potato fields of Northeastern Colorado. It has been important to know the periods of greatest abundance in timing the application of dust and spray in the control of larval injury on the tubers.

LESLIE B. DANIELS, *Colorado Agricultural College.*

**Winter Mortality of the Camphor scale and Dictyosperma scale in 1933 at New Orleans, La.** In a previous note[1] on the winter mortality of three of the most injurious insects in New Orleans it was reported that, following a freeze in January, 1924, when the Weather Bureau recorded minimum temperatures of 26° and 19° F. on two successive days, about 16 per cent of the overwintering females of the camphor scale, *Pseudaonidia duplex* (Ckll.), were killed by the low temperatures. The mortality of the dictyosperma scale, *Chrysomphalus dictyospermi* (Morg.), was about 99.6 per cent and of the Florida red scale, *Chrysomphalus aonidum* (L.), about 99.9 per cent. The mortality of the camphor scale experienced in 1924 had little effect upon intensity of the subsequent infestation. However, the Florida red scale apparently failed to survive except in some greenhouses, and since that time has never become a pest of any importance in New Orleans. A few dictyosperma scales survived in some locations and there has since been a gradual increase in the infestation in this district.

On February 9, 1933, a minimum temperature of 20° F. was recorded by the Weather Bureau, and at our laboratory on the outskirts of the city a thermograph registered 17.5° F. The temperature was below the freezing point for about 18 hours. For several weeks previous to this time the temperatures had been generally above the normal. It was thought that a comparison of the mortality experienced this year with that found in 1924 would be of interest, although, owing to the scarcity of the Florida red scale, such a comparison could be made only for the camphor and dictyosperma scales. In addition, any information on the susceptibility of the camphor scale to low temperatures is of especial value because of its bearing upon the possible limits of distribution of this insect. Up to this time no infestations have been discovered north of Louisiana, and the scale is largely confined to the central and southern parts of the State.

[1]1924. Catchings, Thos. F., and Whitcomb, W. D. Notes on winter mortality of the three coccids, *Pseudaonidia duplex* (Ckll.), *Chrysomphalus aonidum* (Linn.), and *Chrysomphalus dictyospermi* (Morg.), at New Orleans, Louisiana. Jour. Econ. Ent. 17:604–606.

When the prediction of low temperatures was received February 8th, camphor twigs heavily infested with the camphor scale were taken from the field and brought to the laboratory for counts. The camphor scale passes the winter in the adult stage and the dead immature scales as well as dead adults of the older broods were classified separately and eliminated from further consideration. On March 2nd, another count was made from uninjured twigs to determine the mortality caused by low temperatures of February 9th. By this time a number of young had emerged from beneath the scale coverings. These have also been disregarded in obtaining the mortality shown in the last column of Table 1.

TABLE 1. DISTRIBUTION OF STAGES AND MORTALITY

| Date counted | Living scales in each stage | | | | First instar (new brood) | Overwintering scales | |
|---|---|---|---|---|---|---|---|
| | White | Pink | Gravid | Reproducing | | Counted | Dead |
| | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Number* | *Per cent* |
| February 8.. | 1 | 2 | 3 | 95 | 0 | 1,966 | 10.0 |
| March 2.... | 0 | 1 | 2 | 58 | 39 | 2,070 | 47.0 |

In order to determine what part of this increase of 37 per cent in mortality was caused by freezing, the results were compared with changes in natural mortality found in counts made at weekly intervals during 1926, 1927, and 1928. It was found that in no two of the four years was the population distribution identical and that the changes that occurred were due partly to weather conditions. The counts made February 8, 1933, represented the time when the maximum percentage of scales was reproducing. In no other year was the peak so high as 95 per cent. Sometimes the proportion reproducing rose to a sharp peak, and in 1926 there was a flat-topped curve caused by low temperatures which prevented the young from emerging.

Because of the different rates of change of the distribution of stages, the mortality trends which existed during the years in question were estimated in three ways: (1) by a comparison of the mortality at the peak of production with that 22 days later; (2) by a comparison of the mortality at the peak of production with that at the time 39 per cent of the population were in the first instar; and (3) by a comparison of the mortality at the time 39 per cent of the population were in the first instar with that observed 22 days earlier.

It was found that whatever was taken as the proper interval to use in estimating the normal trend in mortality between the freeze and the time of counting in 1933, the maximum change for the period in 1926, 1927, and 1928 was +7 per cent and the minimum 0 per cent. It appears therefore that between 30 and 37 per cent of the overwintering scales on wood uninjured by the freeze were killed by the low temperatures of February 9, 1933. The actual mortality on camphor trees was considerably higher than this because many of the younger twigs were killed. Since the active crawler has a tendency to migrate to the younger growth, a large proportion of the living scales were on wood that was frozen.

No field counts were made on the dictyosperma scale previous to the freeze, but on March 30 a number of *Podocarpus* leaves heavily infested with this scale were examined to determine the proportion of dead insects. It was found that out of 2,247 scales, 2,167, or 96.4 per cent, were dead. All of the immature stages were dead with the exception of 23 of the first instar, which had evidently emerged since the freeze and were not considered in calculating the above percentage. A number

of the living adults were reproducing, and eggs and crawlers were found beneath the coverings. In weekly seasonal-history counts made in 1927, we found that the mortality ranged between 30 and 40 per cent during the winter. While enough dictyosperma scales have been killed to reduce the infestation greatly, it is probable that no infestations have been eradicated. The insect is a rapid breeder, as many as six generations having been reared in the laboratory in one year, and the infestations may be restored to their original status in a short time.

A. W. CRESSMAN and L. T. KESSELS, *U. S. Bureau of Entomology, New Orleans, La.*

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## CONFERENCE OF CONNECTICUT ENTOMOLOGISTS

The tenth annual conference of entomologists working in Connecticut was held in the Assembly Room at the Agricultural Experiment Station, New Haven, on Friday October 27, 1933. Professor J. A. Manter was elected chairman and 60 were present. Luncheon was served at the Station. Director Slate, Dr. Glasgow and Mr. Worthley were unable to be present. Mr. Worthley sent a paper that was read by Mr. Johnson. In other respects the following program was carried out:

Greeting, Director William L. Slate, New Haven.

Entomological Features of the Season of 1933, Dr. W. E. Britton, New Haven.

Recent Termite Depredations in Connecticut, M. P. Zappe, New Haven.

Insect Work in Civilian Conservation Corps Camps in Connecticut, G. H. Plumb, New Haven.

Recent Developments on the Gipsy Moth Project, A. F. Burgess, Greenfield, Mass.

The Status of the Japanese Beetle in the United States in 1933, L. H. Worthley, Harrisburg, Pa.

The Japanese Beetle and the European Corn Borer in Connecticut in 1933, J. P. Johnson, Shelton.

Notes on the White Birch Leaf Miner, *Phyllotoma nemorata* in New York, Dr. R. D. Glasgow, Albany, N. Y.

Inspection of Special Exhibits and of the Department of Entomology.

The Strength of Caterpillars, Prof. J. A. Manter, Storrs.

Round Table Discussion on Collecting Lepidoptera, John V. Schaffner, Melrose Highlands, Mass.; Otto H. Schroeter, Union, Conn.

New Angles in Relation to Shade Tree Pests, Dr. E. P. Felt, Stamford.

The Control of Fleas in Households, B. H. Walden, New Haven.

Studies on the Potato Flea Beetle, Neely Turner, New Haven.

Experience with Lead Arsenate Substitutes, Dr. Philip Garman, New Haven.

Sprays for the Control of the European Pine Shoot Moth, Dr. R. B. Friend, New Haven.

The following were present: I. L. Bailey, Greenfield, Mass.; S. C. Ball, R. M. Bond, R. C. Botsford, W. T. Brigham, W. E. Britton, New Haven; R. C. Brown, Melrose Highlands, Mass.; A. F. Burgess, Greenfield, Mass.; T. M. Cannon, Springfield, Mass.; C. W. Collins, Melrose Highlands, Mass.; O. B. Cooke, Danielson; R. G. Cooper, South Manchester; S. S. Crossman, Greenfield, Mass.; R. M. DeCoursey, Storrs; L. A. DeVaux, Shelton; H. C. Engelhardt, New Haven; E. P. Felt, Stamford, W. O. Filley, H. J. Fisher, R. B. Friend, New Haven; C. W. Frink, Willimantic; W. C. Hall, Storrs; P. Hansling, Jr., R. C. Hansling, Hartford; H. A. Hulse, P. Garman, New Haven; G. H. Geissler, Vincennes, Ind.; J. P. Johnson, Shelton; J. W. Kelley,

II, Storrs; R. E. Kimport, New Haven; D. S. Lacroix, Amherst, Mass.; J. W. Longo, Danielson; H. J. MacAloney, New Haven; J. A. Manter, Storrs; J. J. McDonald, Bridgeport; J. A. McEvoy, Putnam; B. W. McFarland, New Haven; W. J. Nalewaik, Bridgeport; D. L. Parker, Melrose Highlands, Mass.; T. Parr, Clinton; G. H. Plumb, New Haven; J. E. Riley, Jr., New Haven; A. A. Saunders, Fairfield; J. V. Schaffner, Melrose Highlands, Mass.; J. C. Schread, New Haven; O. H. Schroeter, New London; C. E. Shepard, Mount Carmel; R. A. Spencer, Bloomfield; G. R. Smith, New Haven; L. R. Stark, Greenfield, Mass.; G. A. Thompson, Jr., Kingston, R. I.; J. F. Townsend, H. H. Townshend, N. Turner, New Haven; A. M. Vance, Arlington, Mass.; B. H. Walden, New Haven; T. R. Ward, New London; A. J. Warren, A. S. West, Jr., New Haven; M. P. Zappe, New Haven.

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## PROPOSALS REGARDING THE JOURNAL OF ECONOMIC ENTOMOLOGY

The Journal of Economic Entomology has occupied an important place in the field of economic entomology since its establishment 26 years ago. Those who have had to do with the management, and particularly the man who has been its editor from the beginning, E. Porter Felt, deserve the highest praise for their unselfish devotion to the Journal's interests. The recent volumes of the Journal are larger by threefold than the earlier volumes; membership in the organization has greatly increased; and the field covered by articles in the Journal has become greatly enlarged and diversified. With such changed conditions it naturally follows that a discussion of possible changes in the Journal itself might be in order.

The undersigned have been appointed by President Hinds as a committee to consider the publication policy of the Journal of Economic Entomology. In order to get something tangible before the membership, it has been decided to submit certain definite proposals to the active membership of the Association for decision. The committee will attempt to determine, with due consideration to the results of the canvass, to what extent the proposals receiving favorable vote may be carried out in practice. Recommendations will then be presented before a regular winter meeting of the Association for final action.

A post card will be sent to the active members of the Association, at about the time of the appearance of this notice in the Journal, on which an expression of approval or disapproval is asked on each of the following proposals. Please return promptly the self-addressed reply card

(1) TYPOGRAPHY.—The printing of more material per page is recommended by the use of solid instead of leaded type. With the same 10-point type the lines per page would be increased from 41, as at present, to 53, as in the Journal of Agricultural Research. Abstracts, Scientific and Current notes should be set in 8-point solid type, such as quotations in the Journal of Agricultural Research. Tabular material in the Journal could be improved and condensed by the use of 6-point or occasionally 8-point type. Photographs should appear only for the purpose of a better understanding of the paper.

(2) REPRINTS.—25 reprints of each paper shall be furnished on request to the authors without charge, and additional reprints shall be supplied at cost. Income from the sale of additional reprints on a cost basis should be credited to the Journal account and not included with dues in the Association account, as at present.

(3) FINANCIAL POLICY.—The entire income from the Journal shall be devoted to its publication and administration, and none shall be diverted to the so-called "Perma-

nent Fund." During the last three years $1650 has been transferred to the Permanent Fund from the Journal account, and $2650 from the Association account. The fund is now large enough to care for emergencies and it is believed further additions should be restricted to surplus income from dues in the Association account.

(4) LENGTH OF PAPERS.—The present restriction on the length of articles in the Journal shall be changed from a paper basis to a member basis. The following plan is believed to be equitable for such restrictions: Each member is to be allowed a total of 8 pages annually, exclusive of abstracts. In cases of joint authorship, the addition of 1 or more members as authors of a given paper shall add 4 pages to the free page allotment of that paper, which addition shall be assessed equally against the annual free allotment of such additional member-authors. If a member does not publish in one year, or uses less than ½ of his free page allotment, he may use 12 pages the following year; if he does not publish for 2 years or more, or has used less than ⅓ of his free page allotment over this period, he may use 16 pages without extra charge. The charge per additional page shall be at the cost price to the Association. Free publication, as outlined, shall be restricted to members only, except that an annual total of 150 pages may be reserved for especially meritorious papers presented by non-members or by members in excess of their privileged allotment, to be used at the discretion of the Editorial Board.

During the last three years, 23% of the authors (or joint authors) publishing in the Journal were not listed as members, while about ⅓ of the papers exceeded the present 6-page limit. Of authors who were members, 53% published only once in the Journal in three years; 27% twice; 11% three times; 9% published from four to nine times and wrote ¼ of all of the papers by members, a disproportionate share of the available free space in the absence of selection based on merit.

(5) EDITORIAL POLICY.—The editorial policy of the Journal shall provide for the critical review of contributed articles before their acceptance for publication, as is customary in other scientific journals. Entomologists in certain institutions have the advantage of critical examination of the manuscripts before publication, while other contributors are not so safeguarded. It is believed that the following policy would benefit the author, raise the standard of the Journal, and conserve space without unduly burdening the editor or any one member of the Editorial Board: At the present time contributed articles not appearing in the proceedings of any meeting occupy about ⅓ of the space devoted to papers in the Journal. If the next section is adopted, all papers would be "contributed articles."

(a) *Instructions to Authors.*—The Journal will accept manuscripts bearing on economic entomology. Authors must observe the utmost brevity consistent with clarity of presentation. Manuscripts shall be addressed to specialists in the particular fields rather than to the general reader. Extensive reviews of the literature ordinarily should be omitted. When well-known or previously published procedures have been followed in the experimental work, they shall be designated or referred to only. Since original data are often of more lasting importance than the summaries, authors should be urged to include the original numerical data of most papers in one or two compact tables for reference. Papers shall contain a few introductory sentences stating the significance and main objectives of the investigation, and at the end a brief summary of the results obtained. To facilitate action by the Editorial Board, it is desirable

that each manuscript be accompanied by a statement that it has been read critically and approved by one or more persons (named) familiar with the subject. Two copies of the papers shall be submitted to the Editor, who will record on them the date of receipt for publication.

(b) *Editorial Board.*—The Journal shall be managed by an editor, business manager, and an editorial board of 12 members selected by the Executive Committee and representing different subdivisions of entomology, such as general entomology, insect biology, ecology, chemical and cultural control, physiology and toxicology, biological control, medical and veterinary, apiculture, plant quarantine and inspection, and extension.

Members of this board shall serve for 3 years, with 4 new members selected each year. This board shall supersede the present Advisory Board and name the editor and business manager of the Journal.

(c) *Method of Reviewing.*—All contributed papers shall be passed by 2 or more members of the Editorial Board before acceptance for publication. The editor will refer manuscripts to members of the board representing the field or related field of the paper. After reading the manuscript, if each believes that the paper has sufficient review for submission, he will return the manuscript to the editor with his own comments. If a further review is believed necessary, he will submit the paper to one or more experts outside of the Editorial Board. Any criticisms by such reviewers that seem valid to the board member will be relayed with additional comments directly to the author for his consideration. Reviewing is intended to insure scientific accuracy and brevity and not a standardized style of writing. Authors shall be notified of the decision of the board within 6 weeks of the receipt of the paper by the editor. If for any reason a paper is considered unsuitable for publication, the author or a board member may appeal to the board as a whole for decision by majority vote.

(6) PUBLICATION OF PROCEEDINGS.—Except for the President's address, the papers listed in the program of all national, sectional, and branch meetings shall be published in the proceedings in abstract only, as is the custom of the American Phytopathological Society and several other scientific organizations. In the case of papers which are to be submitted for publication in the Journal, the abstract shall be restricted to 300 words. If the paper is not to be published in the Journal, 500 words may be used in the abstract. It is proposed that the abstracts be published whether the papers are read or not, and that the proceedings, including minutes and abstracts of papers, be condensed and appear in the first issue of the Journal after the meeting. Despite the small percentage of the membership which is able to attend the meetings, over 60% of the Journal is devoted at present to publishing proceedings. The adoption of the above plan would equalize the opportunity for publication by putting all papers and all members on the same footing; would permit those who could not attend to appear in the proceedings in abstract form and to follow the entire session without the omissions caused by publication elsewhere; and would facilitate the preparation and approval for publication of current work in abstract form which in the final paper might be delayed.

(7) MONTHLY ISSUE OF JOURNAL.—Because of the large size of the present numbers, and to provide for inevitable expansion and more prompt publication of articles, consideration should be given to the possibility of issuing the Journal monthly.

H. J. QUAYLE
C. L. METCALF *Committee*
A. F. BURGESS

## COMMENTS ON PROPOSALS REGARDING THE JOURNAL OF ECONOMIC ENTOMOLOGY

It is to be hoped there will be a general response to the request by a special committee for opinions in regard to the future policy of the Journal. It is obviously desirable that these opinions be based upon the fullest possible information and that they be formulated with some recognition of the possible effects if one or more are adopted. It is with this in mind that the following statements are made, the numerals referring to the numbered paragraphs in the proposals submitted by the committee.

1. This was submitted to a large proportion of the active members in 1929, and the sentiment being approximately fifty-fifty no change was made. The actual saving in cost is approximately ten per cent.

2. Were the Journal to furnish reprints to authors, it would mean the use of funds otherwise available for printed matter. It might cost $500 annually. Reprint income has always been credited to the Journal.

3. The amount diverted to the permanent fund has not been large in proportion to entire expenditures. The desirability of continuing this depends on the purpose of the permanent fund.

4. Increased length of papers presumably means more copy submitted, unless there is a rigid restriction in some other direction. A strictly impartial member allotment would mean one page annually per member. Does the recommendation as to actual cost for excess matter refer to composition charges or entire cost? Present charges are intermediate. The percentage data on authorship are misleading even if correct. They should be interpreted since membership papers appear in the main association sessions and those of sections or branches. There are leaders in all of these divisions, some with broad interests. It is hardly feasible to limit such men to one branch or one section. This is the explanation in large measure of a number of papers by individual members.

5. The editorial policy suggested evidently contemplates a rigid restriction to more technical papers. The Journal is dependent for support upon its subscribers, and they, it should be remembered, represent very divergent interests. Subscription rates of current technical publications indicate a probable trebling of subscription rates if the Journal was limited to technical papers and the volume of matter remains about the same. The changes indicated in sub-paragraphs b and c would eventually mean increased expenditures, and in the case of the latter considerable delay in publication. Authors connected with the Federal Bureau of Entomology, where a method of review is in force, have great difficulty in getting their manuscripts through in time to take their places in the Proceedings, even if the latter are held open to the latest possible date. A question may be raised as to the advisability of publishing the proceedings in abstract under present conditions.

6. This practically means a technical publication and may easily result in greatly increased costs.

7. Monthly issues do not necessarily mean more prompt publication. This latter can be obtained only by increasing the size of the Journal or establishing such rigid restrictions as to cut down greatly the amount of matter submitted for publication.

E. P. FELT

# JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

DECEMBER 1933



The editors will thankfully receive news matter and other items likely to be of interest to our readers. Papers will be published as far as possible in the order of reception, except that papers of reasonable length may be accepted in the discretion of the editor for early publication at $3.00 per page. There is a charge of $3.00 per page for all matter in excess of six printed pages, a part page counting as a full page, this limit not including acceptable illustrations. Photo-engravings may be obtained by authors at cost.

Separates or reprints, if ordered, when the manuscript is forwarded, will be supplied to authors at the rates given below. Note that the number of pages in a reprint may be affected somewhat by the make-up, and that part of a page is charged as a full page. Carriage charges extra in all cases. Shipment by parcel post, express or freight as directed.

One hundred separates or reprints at $1.50 per page or plate. Additional hundreds or less, 4 pages or less, $1.00; 5-8 pages, $1.50; 9-12 pages, $1.75; 13-16 pages, $2.00; 17-24 pages, $3.00; 25-32 pages $4.00. Covers suitably printed on first page only, 100 copies, or less $4.50; additional hundreds, or less, $1.75. Plates inserted, $1.75 per hundred or less. Folio reprints, the uncut folded pages (50 only), sixteen page signature, or less, $3.00. A discount of 10 per cent and 20 per cent from the above prices will be allowed on orders of 500 and 1000 reprints respectively.

A. A. A. S. Winter meetings: 1933-34 Boston; 1934-35 Pittsburgh; Summer meetings: 1933 Chicago. 1934 San Francisco.


A committee on the policy of the Journal is seeking information in relation to certain proposals. These are published on a preceding page. All have advantages and disadvantages. It is hoped that the considerations both for and against these propositions will be carefully weighed, since the ultimate effect may be fully as important as any immediate gain or loss. The Journal, as the official organ of the Association, has endeavored to serve its large and varied membership. It has been a self-sustaining activity and depended entirely or almost entirely upon a very modest subscription rate. A reduction in the number of subscribers would mean either a raising of the subscription rate or curtailment of the amount of printed matter. The restriction of publication to the more technical papers, desirable though this may be from certain viewpoints, may have unanticipated effects. The probabilities are that some changes must be made in the not distant future. The problem is to determine what changes may be practicable.

The program, printed elsewhere in this issue, should be given a more than careful examination. The Secretary made an appeal for comprehensive and informative abstracts. Some papers are accompanied by these and others have none. It is quite possible that in the latter cases the authors found themselves unable to formulate a summary prior to the writing of the paper and that the preparation of this was unavoidably delayed owing to numerous other matters claiming attention. Papers of

both types will be presented at the Boston meeting, and it follows that those who have gone to the trouble of preparing extensive abstracts can take advantage of this information in the program and limit, if they so desire, the presentation of the paper to the more salient and important points and thus possibly leave some time for discussion. Those who have not submitted abstracts cannot profit, if there is profit, by such an arrangement. Those attending the meetings will have an excellent opportunity to decide as to whether the printing of extensive abstracts in the program is advisable or not. Aside from the presentation of scientific data, this meeting will somewhat unwittingly give an actual demonstration as to the relative value of one system as compared with the other. It is hoped that those attending will give this phase of the matter close attention, with the possibility in mind of offering constructive criticism.

## Obituary

### Shinkai Inokichi Kuwana[1]

The eminent Japanese entomologist, Shinkai Inokichi Kuwana, died of heart failure in Tokyo, Japan, July 14, 1933. His loss to the natural sciences is great and he is mourned by entomologists and biologists the world over. Not only in his native land was he recognized as a great student of insects, but also in the United States where he lived six years and where he procured his higher educational training and made many warm personal friends.

He was born in the village of Kurotsuchi-mura, Chikugo-gun, Fukuoka-Ken, Island of Kiushiu, in southern Japan, on May 17, 1872.[2] Here his boyhood was spent on a farm. From his brother, J. K. Kuwana[3], we learn that in early youth he was much interested in natural history. His desire for educational advancement is indicated by the fact that when he was but sixteen years old he was a school teacher in his own village. As a means of preparing for advanced studies, he went to Hawaii at the age of eighteen to learn the English language. He re-

[1]Howard, L. O., A history of applied entomology. Smithsonian Institution, Washington, D. C., pp. 341, 343, 345, 346; pl. 31, fig. 2, 1930.

[2]Registered simply from Fuknoka, Japan, as the place of birth and May 17, 1872 as the date. This and other information concerning his connection with Stanford University were kindly furnished by the registrar, J. P. Mitchell under date of Sept. 25, 1933.

[3]J. K. Kuwana, Los Angeles, California, kindly furnished many facts concerning the intimate life of Mr. Kuwana as well as the photograph reproduced herewith.

mained there three years during part of which time he acted as an interpreter on a sugar plantation.

In 1895 he came to the United States and entered Cornell University, Ithaca, New York, registering from Higashi-Karuizawa, Aoki-Cho, Yokohama, Japan. He remained there until 1897. Dr. J. G. Needham, who kindly furnished this bit of information states: "I was here during the last year of his residence and knew him, but not intimately, as a quiet, careful student; and I have corresponded with him intermittently ever since and have exchanged papers with him."

He entered Stanford University, Palo Alto, California, as a special student in 1897. He graduated with the A. B. degree in entomology in 1899. In September of that year he was admitted as a graduate student and received the A. M. degree in the Department of Zoology in 1901. His master's thesis was entitled: "Coccidae (scale insects) of Japan." During this period he was one of a group of students studying entomology under Vernon L. Kellogg, practially every one of whom have since become leaders in his chosen specialty. As a student Kuwana became interested in the Mallophaga and certain families of Homoptera, especially the Coccidae, Aleyrodidae, and Aphididae.

During this period in California he also made many contacts with local entomologists and learned something concerning the importance and value of plant quarantine and methods used in combating injurious insects in California.

Following his return to his native Japan, he was appointed a member of the Imperial Central Agricultural Experiment Station at Nishigahara, Tokyo, in 1909 and was made director of the newly organized Imperial Plant Quarantine Station at Yokohama in 1914 and thus became the first and leading authority on plant quarantine in his own country. During the years that have followed he not only supervised the plant quarantine work but has also acted as chief entomologist for the Ministry of Agriculture and Forestry and of late years maintained headquarters at Tokyo, where he has occupied a strategic position in relation to all foreign entomologists visiting Japan.

Kuwana was nominated as a foreign member of the American Association of Economic Entomologists by Dr. L. O. Howard in December 1909 and was duly elected and had continued as such to the time of his death.

During the summer of 1919 he again visited the United States and made a general survey of the entomological activities in this country and formed many new acquaintances.

In recognition of his valuable services, high state honors were conferred upon him by the Emperor of Japan. He is survived by his wife

S. I. KUWANA and MRS. KUWANA.
Photograph loaned by J. K. Kuwana.

and an only son, Juichi Kuwana, of the Kyoto Imperial Sericultural College. He was buried in Tokyo.

He began publishing on insects in 1901 and has continued to produce worthy articles throughout his busy life. Although many of his papers are printed in Japanese nearly all of his technical contributions are in English. He came to be a leading world authority on the Coccidae of Japan and his papers are of an excellent order. Among his more important contributions are the following:

COCCIDAE

1901. Notes on new and little known California Coccidae. Proc. California Acad. Sci. (3) vol. 2 Zool. p. 399–408, 2 pls.

1902. Coccidae of Japan [I]. Proc. California Acad. Sci. (3) Zool. p. 43–98, 7 pls.

—— Coccidae from the Galapagos Islands. Jour. New York Ent. Soc. vol. 10 p. 28–33, 2 pls.

1904. The San Jose scale in Japan. Imperial Agr. Exp. Station Japan, Tokyo. 33 pp. 8 pls. (2 colored).

1907. Coccidae of Japan [II]. Imperial Agr. Exp. Station Japan, Tokyo. vol. 1 No. 2, p. 177–231, 9 pls.

1909. Coccidae of Japan III. First supplemental list of Japanese Coccidae, or scale insects, with descriptions of eight new species. Jour. New York Ent. Soc. vol. 17 p. 150–158, 3 pls.

—— Coccidae of Japan IV. A list of Coccidae from the Bonin Islands (Ogasawara-Jima), Japan. Jour. New York Ent. Soc. vol. 17 p. 158–164, 3 pls.

1914. Coccidae of Japan. P. C. Jour. Ent. & Zool. vol. 6 p. 1–8, 3 pls.

1916. Some new scale insects of Japan. Annot. Zool. Japanenses. vol. 9 p. 145–151, 1 pl.

1917. A check list of the Japanese Coccidae. Coll. Essays for Mr. Yasuchi Nawa, Yokohama, Japan. 19 p. Oct. 8.

1922. Studies of Japanese Monophlebinae. I, The genus *Warajicoccus*. Bul. Imperial Plant Quar. Sta. No. 1, 58 pp. 12 pls. (5 colored). II, The genus *Icerya*, No. 2, 43 p. 14 pls. (1 colored.)

1923. Descriptions and biology of new or little-known coccids from Japan. Bul. Imperial Plant Quar. Sta. Bul. 3, p. 1–65, pls. i–xiv.

—— The Chinese white-wax scale, *Ericerus pela* Chavannes. Philippine Jour. Sci. vol. 22 p. 393–405, 2 pls.

1925. The diaspine Coccidae of Japan I. *Genera Poliaspis, Ischnaspis,* and *Parlatoria*. Dept. Agr. & Comm. Bur. Agr. Injurious Insects & Pest Ser. No. 14, 18 p. 3 pls.

—— The diaspine Coccidae of Japan II. The genus *Lepidosaphes*. Dept. Finance, Japan Imperial Plant Quar. Service. Rev. Bur. Tech. Bul. 2, 42 p. 11 pls.

—— The diaspine Coccidae of Japan III. The genus *Fiorina*. Dept. Finance, Japan Imperial Plant Quar. Service. Rev. Bur. Tech. Bul. 3, 20 p. 7 pls.

1926. The diaspine Coccidae of Japan IV. Genera *Cryptoparlatoria, Howardia, Sasakiaspis, Diaspis, Aulacaspis, Pinnaspis,* and *Prontaspis*. Dept. Finance, Japan Imperial Plant Quar. Service. Rev. Bur. Tech. Bul. 4, 44 pp. 12 pls. (1 colored.)

1927. A new species of the genus *Fiorina* from Japan. Annot. Zool. Japanenses. vol. 11 p. 151–154, 1 pl.

—— A list of Coccidae (scale insects) known from China. Lingnaam Agr. Rev. vol. 4 p. 70–72.

1928. The diaspine Coccidae of Japan V. Genera *Chionaspis*, *Tsukuhiaspis*, *Leucaspis*, and *Nikkoaspis*. Min. Agr. & Forestry, Japan. Dept. Agr. Sci. Bul. 1, 39 p. 9 pls.

1931. The diaspine Coccidae of Japan VII. Genus *Phenacaspis*. Min. Agr. & Forestry, Japan. Dept. Agr. Sci. Bul. 2, 14 p. 3 pls.

—— The genus Kermes of Japan. Min. Agr. & Forestry, Japan. Dept. Agr. 29 p., pls. iv–xi (1 colored.)

—— On the genus Kermes in Eastern Asia. Ronytu, vol. 5 p. 47–51.

1932. Two new conifer-infesting scale insects from Japan. Philippine Jour. Sci. vol. 48 no. 1, p. 51–55. 3 figs.

—— The genus *Aclerda* in Japan, including Formosa. Min. Agr. & Forestry, Japan. Dept. Agr. p. 57–67, 4 figs.

1933. 1. The diaspine Coccidae of Japan, VII. II. Key to genera of Diaspinae in Japan. III. An index to species of coccids recorded in the diaspine Coccidae of Japan, I–VII. Ministry of Agr. and Forestry, Japan. Dept. Agr., Sci., Bul. 3, 51 p. 11 pls.

(This "treatise is the last and posthumous report of his studies concerning Japanese Diaspine Coccidae by the late Mr. Inokichi Kuwana, and completes his studies of Diaspinae.")

### Mallophaga

1902. Mallophaga from the Galapagos Islands (With Vernon L. Kellogg). Proc. Washington Acad. Sci. vol. 4 p. 457–499.

### Aleyrodidae

1909. Aleyrodidae of Japan (In Japanese). Insect World. vol. 13 no. 1 p. 2–6; no. 10 p. 9–11; vol. 4 no. 1 p. 13–15.

1910. Aleyrodidae of Japan (In Japanese). Insect World. vol. 4 no. 2 p. 8–9; no. 3 p. 7–8.

1911. White flies of Japan. P. C. Jour. Ent. & Zool. vol. 3 p. 620-627, figs. 207–208.

1927. On the genus *Bemisia* found in Japan. Annot. Zool. Japanenses. vol. 2 p. 245–252.

1928. Aleyrodidae or white flies attacking citrus plants in Japan. Min. Agr. & Forestry, Japan. Dept. Agr. Sci. Bul. 1 p. 41–78, pl. x.

### Aphididae

1918. Some Japanese Aphididae (with E. O. Essig). Proc. Calif. Acad. Sci. (4) Zool. vol. 8, no. 3 p. 35–112, 40 figs.

### General

He is one of the authors of the splendid new book on Japanese insects entitled "Nippon Konchu Zukan. Iconographia Insectorum Japanicorum. Hokurukan, Tokyo, 1932. In Japanese. It contains more than 2400 pages and illustrations of more than 4000 species of insects. (Reviewed in Jour. Econ. Ent., vol. 25, pp. 1117–1118, 1932.)

E. O. Essig

# Current Notes

Z. P. Metcalf, Professor of Zoology and Entomology, State College of Agriculture and Engineering of the University of North Carolina and Entomologist of the Agricultural Experiment Station has been appointed a member of the Administrative Council of the University by President Graham.

Mr. Lee A. Strong, who for the past four years has been Chief of the Bureau of Plant Quarantine, became Chief of the Bureau of Entomology, October 1, 1933, succeeding Dr. Marlatt who retired on September 30. Mr. Strong was formerly Assistant Director of Agriculture in California and served also as a specialist in plant quarantine in the U. S. Dept. of Agriculture before becoming Chief of the Bureau of Plant Quarantine. Avery S. Hoyt, formerly Assistant Chief of the Bureau of Plant Quarantine is acting Chief.

"A Summary of Recent Results with Pyrethrum as an Agricultural Dust." This is an eight-page multigraphed memorandum dated September 1933, issued by John Powell & Company, of 114 East 32nd St., New York City. Although their names do not appear, it was compiled by Drs. Alfred Weed and M. D. Leonard, Research Entomologists for this company. A resume of a considerable amount of reliable experimental data is contained in this "Summary" and entomologists who are interested may obtain a copy by writing direct to the New York Office.

Mr. J. N. Knull, formerly Assistant Entomologist and Specialist in Entomology, Bureau of Plant Industry, Penna. Dept. of Agriculture and recently Research Entomologist with the Mount Alto Forestry School has been appointed Curator of Insects and Assistant Professor of Entomology in the Dept. of Zoology and Entomology, Ohio State University, effective January 1, 1934. He will have charge of the arrangement and care of the Osborn collection of Homoptera, the Wenzel collection of Coleoptera, the Tallant collection of Lepidoptera, and the University collection.

Dr. Charles L. Marlatt, who reached his seventieth birthday on September 26, retired September 30, 1933, as Chief of the Bureau of Entomology, U. S. Department of Agriculture. Before coming to the Department, in 1889, Dr. Marlatt was assistant professor of entomology and horticulture at the Kansas State Agricultural College, where he had received B. S. (1884), M. S., and D. Sc. degrees. Dr. Marlatt soon became associated with the administrative work of the Bureau of Entomology and served as assistant chief from 1894 to 1927. During that period he made important contributions to the information on the life-history, habits, and methods of controlling important plant pests, particularly the forms that attack fruit trees and cereal and forage crops, and stored-product and household insect pests. He also conducted technical studies on the classification of insects. Dr. Marlatt is probably best known for his work which led to the passage of the Plant Quarantine Act of 1912. On the evening of his 70th birthday, September 26, 1933, he was given a farewell dinner at the Cosmos Club by his associates and friends in the Department. Upon his retirement, September 30, he was presented with a watch, suitably inscribed, by his associates in the Bureau.

## Horticultural Inspection Notes

In a recent issue of the "Boll. della Soc. Ent. Italiana," an earlier report that the San Jose scale had been found in Italy, is denied by Trinchieri.

The Territory of Puerto Rico has established terminal inspection of parcel post shipments of plants and plant products under the provisions of the act of March 4, 1915 (Sec. 596, Postal Laws and Regulations). The inspection service is maintained at San Juan only.

On November 4 the Bureau of Plant Quarantine of the United States Department of Agriculture at Washington, D. C., moved from the Lemon Building at 1729 New York Ave., to Building "C", at 7th & B Sts., S. W. This is the same building in which most of the divisions of the Bureau of Entomology are located.

According to an announcement in a recent railway circular, a quarantine relating to strawberry yellows was placed by the Director of the Oregon State Department of Agriculture on July 10, requiring certification of strawberry plants transported from Josephine Co., Ore., to any other part of the State.

The State of Louisiana placed rules on October 15, requiring State nursery inspection of cut flowers shipped into or within the State, for the reason that "cut flowers * * * are responsible for the dissemination of insect pests and plant diseases * * *." Inspection is required of "the immediate premises and plants on which the cut flowers were grown."

The Eastern Plant Board met at Philadelphia on November 22, immediately preceding the meeting of the Eastern States Entomologists on the two following days. Among the important subjects discussed were the Dutch elm disease outbreak in New Jersey and New York, and various Federal plant quarantine and insect suppression projects, including the gypsy moth and Japanese beetle problems.

Scrubbing, immersing or spraying with an insecticide containing 2 per cent of oil is the treatment for citrus stock which the Florida State Plant Board now requires of nurserymen in that State, under an amendment of Rule 8-E placed on September 18. Formerly the stock was required to be scrubbed in a fish-oil solution, before being shipped. Rule 8-C, which prohibited the movement of undefoliated citrus stock except under certain conditions was repealed on the above date.

On October 25 the Department of Agriculture held a conference at Washington, D. C., to re-examine the underlying principles involved in the interpretation and enforcement of the Nursery Stock, Plant, and Seed Quarantine No. 37. The hearing was well attended and various points of view were expressed by the different interests represented, which included commercial nurserymen, garden clubs, florists, bulb growers, citrus growers, plant quarantine officers, and others.

A special quarantine to prevent the further introduction of the Dutch elm disease into the United States was issued on October 21, 1933. Under the provisions of this quarantine and of Circular BPQ-356, which gives detailed information concerning it, the entry of elm burl logs into the United States is permitted on condition that the logs are free from bark and from wood-burrowing insects, and on condition that the logs are treated at a temperature of 180° F. or over for at least two hours.

A conference at which plant quarantine officers, phytopathologists, foresters, and others, discussed the problems arising from the New Jersey and New York outbreak of the Dutch elm disease, was held at Washington on October 26. At that conference, Mr. R. Kent Beattie, representing the Bureau of Plant Industry, stated that the number of trees found infected this season up to that time was 603 in New Jersey; 46 in New York; one in Connecticut, one in Maryland, and one in Ohio; a total of 652. The safeguards employed by the State of New Jersey to keep infected trees from being shipped outside the infected areas, were described by representatives of the New Jersey State Department of Agriculture.

The October issue of the International Bulletin of Plant Protection published at Rome, reports the finding of the Colorado potato beetle in England. Three specimens were found, only one of which was alive, not far from the mouth of the Thames River. All field crops of potatoes within 16 kilometres of Tilbury in Essex, and within 8 kilometres of Gravesend in Kent were sprayed by the government with an arsenical wash and the soil of the allotment in which the beetles were discovered was fumigated. The treatment will be repeated during the autumn.

Recent developments in the phony peach disease situation include the revocation or modification of Illinois and Arkansas regulations, the problem to be handled in the former State without the use of quarantine measures and in the latter by special inquiry as to satisfactory inspection and proper sanitation measures before shipping permits are issued to nurserymen in the infected States. The States of Alabama and Louisiana have placed regulations relating to interstate and intrastate movement. In the case of Alabama, certification is based on (1) a disease-free county; or (2) mile-radius inspection; or (3) culling to eliminate borer-infested trees. In Louisiana the destruction of all infected trees in the State is required and certification for shipping is based on conditions similar to (2) and (3) above.

According to a statement presented by Mr. L. H. Worthley at a hearing to consider the extension of the Japanese beetle quarantine to the states of Maine and West Virginia on October 24, a few beetles were captured at each of a large number of different points south and west of the regulated areas this past summer. The only localities at which ten or more such beetles were found outside the regulated areas were Portland and Waterville, Maine; Berwyn, Bethesda, Bladensburg, Chevy Chase Hyattsville, Riverdale, and Silver Springs, Maryland; Salamanca, New York; Erie, Pennsylvania, and Keyser, West Virginia. In the case of other points, it is considered by the department that the evidence does not necessarily indicate an established infestation.

A public hearing was held at Memphis, Tenn., on November 20, at which consideration was given to the extension of the pink bollworm quarantine regulations to the State of Georgia. Extension of the quarantined area in Florida and Texas was also discussed. The Georgia reports involve only about eleven specimens found in gin trash and in a field near the line between Berrien and Tift counties. The Texas discoveries consist of the taking of a small number of specimens at a number of points in Hockley, Terry, Dawson, and Gaines counties, and in gin trash from cotton grown in Lea County, New Mexico. The Gaines County area was brought under quarantine in an amendment issued on October 24. In announcing the hearing, the Department stated that it did not consider the situation in either the Georgia-Florida dis-

trict or the Texas-New Mexico area with undue alarm, owing to the lightness of the infestations and the fact that similar infestations in the past have yielded to eradication measures.

Practically all the agricultural laws of California formerly in effect were revised or revoked under the new Agricultural Code adopted at the last session of the legislature. A broad definition of "pests" written into the law, has the effect, we are info med, of placing weed seed under quarantine control, "so that prevention of the introduction of noxious weeds is now as much a part of the duties of [California] quarantine inspectors as the prevention of the introduction of injurious plant diseases and insects." Some of the old laws which were repealed related to date-palm scales, walnut codling moth, and the regulation of transportation of grapevines for fuel. Retained in the new law are the provisions for inspection of incoming shipments of nursery stock at destination and for proper disposition when there is "reasonable cause to presume" that it may be infested or infected. All plant quarantine regulations involving another State are subject to approval of the Governor.

Under a recent amendment to the Wisconsin nursery inspection law, a reciprocity fee of $10 may be charged out-of-State nurserymen, according to the Florists' Review of September 14. Until recently Wisconsin has not charged out-of-State nurserymen for doing business "but with the continual increase in the number of States requiring a dealer's license fee for Wisconsin nurserymen," the Florists' Review statement reads, "It seemed advisable to try to check this by a reciprocity fee which would make it possible to charge other States a license fee when they charge Wisconsin nurserymen for such a purpose." Provision is made in the amendment for the commissioners of the Wisconsin State Department of Agriculture and Markets to enter into reciprocal agreements with officers of other States "under which nursery stock owned by nurserymen or dealers of such States may be sold or delivered in this State without the payment of a Wisconsin registration fee, provided like privileges are accorded to Wisconsin nurserymen or dealers in such other States* * *.

Prof. A. E. Stene, Chief, Bureau of Entomology and Plant Pest Control of Rhode Island, sends the following statement as to the growth of nurseries and nursery inspection in the State: "Twenty-nine years ago, there were only twenty nurseries and none contained over ten acres. The total area of nurseries perhaps did not amount to much over 60 or 75 acres. According to our records for last year there are now 76 nurseries, 2,994 acres in property and 823 acres in stock, 137,365 square feet of greenhouses, nearly 81,000 square feet of hot bed sash and 1,250,000 square feet in propagating beds. Three nurseries contain over 100 acres and one over 200 acres. The value of this business in 1904 would probably have amounted to not over $60,000 or $70,000. 1931 which was a better test of the status of the business in Rhode Island than 1932 gave us a total estimated value of over $750,000. It is needless to say that where one man was able to readily do the work in the time available in 1904, it now takes a considerably larger number of workers."

The Rhode Island State Department of Agriculture is planning a special inspection during the winter and spring to determine whether there are any infestations of the European pine shoot moth. None were found in the ordinary course of inspection during the middle of the summer, but a more careful survey of the plantings is believed desirable in view of the rather heavy outbreak of this insect in Connecticut.

# INDEX


abbreviatus, Diaprepes, 1172
Abia americana, 293
abnormis, Leptomastidea, 857
Adelphocoris rapidus, 943
Aegeria exitiosa, 903
Aenoplex betulaecola, 789
aequalis, Ephialtes, 789
Agitation, spray tank, 1106
Agrilus anxius, 47
  bilineatus, 47, 977
Agromyza pusilla, 515
Agrotis ypsilon, 911
Airplane spraying, 1052
alacris, Cryptus, 789
Allen, T. C., 1108
Allorhina nitida, 46
Alsophila pometaria, 1030
ambigua, Hippodamia, 1033
Ambrosia beetle, pitted, 47
americana, Abia, 293
  Periplaneta, 1162
  Schistocerca, 300, 692
Anabasine, 500
Anastatus semiflavidus, 797, 799
ancylivorus, Macrocentrus, 280, 330, 986
Anderson, L. D., 129
Anetia dimmocki, 153
Aneuraphis roseus, 475
Angoumois grain moth, 402
angustus, Sympherobius, 859
annulipes, Chelonus, 95
Anomala orientalis, 80
Anthonomus eugenii, 1095
  grandis, 940, 1125
Anthrenus verbasci, 446
anxius, Agrilus, 47
Aonidiella aurantii, 851, 1140
  *See also* Chysomphalus
aonidum, Chrysomphalus, 1177
Aphids, 841, 845
Aphis gossypii, 453
  lions, 977
  melon, 453
Apiary inspection, 194
apicitripunctella, Recurvaria, 47
Apis sp., African, 998
Apple aphis, rosy, 475
  curculio, 420
  leafhopper, 325
  maggot, 344, 349, 1108
  red bug, 478
  worm, lesser, 509
Armillaria mellea, 640
Arsenical residues, 572
Arsenious acid, 486
Ascogaster carpocapsae, 790
Asiatic beetle, 633
  garden beetle, 80, 633
Aspidiotus hederae, 632
  perniciosus, 470, 476, 1106
  tsugae, 424
associatus, Chlamydatus, 1173
atriplicis, Megalopsallus, 953
Attagenus piceus, 446
Aull, L. E., 913
aurantii, Aonidiella, 851, 1140
  Chrysomphalus, 1016
Autoserica castanea, 80, 633
Auxiliary gases, 1031
Azalea leaf scorch, 637
azaleae, Septoria, 637
  Sporocybe, 639
azaleella, Gracilaria, 634

Bailey, S. F., 292, 836
Barber, G. W., 1174, 1175
barberi, Sympherobius, 859
Barium fluosilicate, 233
Bark beetles, 733
Barnes, O. L., 799
Barrett, R. E., 873
Beattie, R. K., 621
beckii, Lepidosaphes, 988
Bedad, W. D., 1128
Bee moth, 177
  "Paralysis," 162
Bees, plants poisonous to, 168
Beech limb borer, 977
  scale, 510
Beekeeping, The New, 155
Bell, R. H., 649
Beet leafhopper, 1011
Beetle trap captures, 296
betulaecola, Aenoplex, 789
Bigger, J. H., 652
bilineatus, Agrilus, 47, 977
Billbug, low tide, 210
Biological Societies Union, 12
bipunctatus, Scymnus, 858
Birch borer, bronze, 47
  sawfly, 732
bissesa, Megalopyge, 295
Bissell, T. L., 176
bisselliella, Tineola, 446
bivittata, Metriona, 151
bivittatus, Melanoplus, 103, 669
Black cutworm, 911
  scale, 1016
  vine weevil, 47, 634
Blanton, F. S., 515, 613
Blatella germanica, 1083
Blatta orientalis, 792, 1162

Blissus leucopterus, 994
Blueberry maggot, 221
bohemica, Rehmiellopsis, 623
Boll weevil, 940, 1125
Bollworm, 957
Borden, A. D., 1106
Botrytis blight, 639
Boyce, A. M., 813, 819
Brachyrhinus sulcatus, 47, 634
Brannon, L. W., 123
Bregmatothrips iridis, 916
brevicomis, Dendroctonus, 297
Brindley, T. A., 1058, 1063
Britton, W. E., 604
Brooks, F. E., 742
Brower, E. A., 732
Bruchus pisorum, 1058, 1063
Buckeye poisoning, 181
Bud blast, 639
Bud moth, 477
Bufo marinus, 67
Bulb flies, 613
  pests, 613
buoliana, Rhyacionia, 48, 57
Burdette, R. C., 672
Burgess, A. F., 35, 51, 598, 1182
Burnside, C. E., 162
Butler, H. G., 982

cactorum, Phytophthora, 638
Caffrey, D. J., 85
calcitrans, Stomoxys, 269
Calcium arsenates, 914
  cyanide, 544
Calendra setiger, 210
Calhoun, P. W., 1125
calidum, Calosoma, 797
California red scale, 1140
californica, Chrysopa, 862
  Frankliniella, 836
  Sympherobius, 859
californicus, Limonius, 1042
Calligrapha philadelphica, 47
Calosoma calidum, 797
  lugubre, 797
  obsoleta, 797
  sycophanta, 797
Camnula pellucida, 104
Camphor scale, 1177
Campbell, F. L., 451, 500
Campbell, R. E., 237
Camphor scale, 988
canavaliae, Elsinoe, 625
Canker worm, fall, 1030
canus, Limonius, 243
Casein ammonia, 880
castanea, Autoserica, 80 633
Castor bean toxicity, 299
Carbolic acid, 543
Carbon disulphide, 887
  tetrachloride, 541
Carpet beetles, 446
carpocapsae, Ascogaster, 790
Carpocapsa pomonella, 358, 364, 373, 380, 383, 392, 438, 1016, 1056, 1112
Carpophilus hemipterus, 516
Carter, R. H., 572, 913
Cattle fly spray tests, 269
cerasi, Myzus, 476
Ceratophyllus idius, 293
Cercospora rhododendri, 635
cerealella, Sitotroga, 402
Chaetexorista javanica, 56
Chaff scale, 988
Chamberlin, F. S., 233, 259
Chelonus annulipes, 95
Cherry aphis, 476
Cherry case bearer, 513, 805
  fruit flies, 431
Chestnut borer, two-lined, 47, 977
Chinch bug, 994
Chinese mantid, 51, 1075
Chionaspis euonymi, 50
  furfura, 912
  pinifoliae, 989
Chlamydatus associatus, 1173
  verbasci, 1173
Chloropicrin, 237
Chrysomphalus aonidum, 1177
  aurantii, 1016
  dictyospermi, 696, 1177
Chrysopa californica, 862
Chrysoplatycerus splendens, 858
Cigarette beetle, 294
ciliata, Corythucha, 49
cilicrura, Hylemyia, 910
cinereum, Physarum, 640
cingulata, Rhagoletis, 431, 825
cinnamomi, Phytophthora, 639
citri, Pseudococcus, 855
Citrus fumigation, 262
  mealy bug, 855
Claassen, P. W., 282
Clancy, D. W., 1171
claripennis, Phorocera, 797
Clothes moths, 446, 720
Cnidocampa flavescens, 54
coccidivora, Laetilia, 50
coccinea, Nectria, 510
Coccus pseudomagnolarium, 298
Cockerell, T. D. A., 1000
cockerelli, Paratrioza, 730, 846, 977
Codling moth, 358, 364, 373, 380, 383, 392, 438, 603, 1013, 1056, 1112
Cole, F. R., 855
Coleophora laricella, 46
  pruniella, 513, 805
Collembola species, 934
Collins, C. W., 54
Color phases, 706
Colorado potato beetle, 995, 1068

comes, Typhlocyba, 719
Common names, 1169
completa, Rhagoletis, 813, 819
Compsilura concinnata, 797
Comparative toxicities, 302
concinnata, Compsilura, 797
Connecticut entomologists, 1179
Conotrachelus nenuphar, 415
conquisitor, Pimpla, 797
contractus, Thylodrias, 509
convergens, Hippodamia, 1033
Copper absorption, 648
Corn earworm, 109, 978
  stalk borer, 1174
corrupta, Epilachna, 115, 123
Cory, E. N., 109
Corythucha ciliata, 49
  salicata, 1090
  ulmi, 49
Corthylus punctatissimus, 47
Cotton insect investigations, 274
  states branch, 929
  flea hopper, 963
  fruiting, 1125
Cracca, 587
crambidoides, Diatraea, 1174
Crambus teterellus, 1117
Cranberry root worm, 632
Crawford, R. F., 846
Cremastus flavoorbitalis, 95
  forbesi, 790
  minor, 790
Cressman, A. W., 295, 1179
Cresylic acid, 566
Crop Protection Institute, 10
Crumb, S. E., 259
Crypticus obsoletus, 911
Cryptolaemus montrouzieri, 856, 1033
Cryptophagus fagi, 510
Cryptus alacris, 789
cucumeris, Epitrix, 1175
Cupples, H. L., 262
curvipes, Lachnopus, 1172
Cuscuta gronovii, 640
Cutright, C. R., 380, 392, 509, 742, 996
cyaniceps, Eupelmus, 652
Cypress leaf miner, 47

Daniels, L. B., 1176
Dasyscypha ellisiana, 622
  willkommii, 622
Davis, J. J., 72, 687
Dawsey, L. H., 736
Dean, F. P., 1056
Dean, R. W., 913
decemlineata, Leptinotarsa, 1068, 1174
DeEds, Floyd, 304
Deemer, R. B., 648
Defoliation data, 51, 995
delicatus, Macrocentrus, 790, 982
Dendroctonus brevicomis, 297
  monticolae, 733
  pseudotsugae, 733, 1128
  valens, 828
Dendrothrips ornatus, 47
Derris, 587, 914, 995
Desmoris fulvus, 652
Diaprepes, abbreviatus, 1172
Diatraea crambidoides, 1174
  saccharalis, 758, 974
Dibble, C. B., 580, 893
Dictyosperma scale, 1177
dictyospermi, Chrysomphalus, 696, 1177
Dietz, H. F., 392
differentialis, Melanoplus, 103, 494, 669
dimmocki, Anetia, 153
Dioctes obliteratus, 790
dipsaci, Tylenchus, 613
Dirks, C. O., 344, 349
dispar, Porthetria, 47
Ditman, L. P., 109
Dodder, 640
domestica, Musca, 486
dominicana, Rhizopertha, 293
Douglas fir beetle, 1128
Draeculacephala mollipes, 282
Drake, C. J., 841
Dried fruit beetle, 516
Driggers, B. F., 1137
dubia, Scolia, 46
Dugas, A. L., 758
duplex, Pseudaonidia, 988, 1177
Dutch elm disease, 621

Ebeling, Walter, 851
Ecker, J. E., 181
Ecological studies, 320
Economic Entomologists, Association
  Chicago Exhibits report, 27
  Codling moth committee, 24
  Eastern Branch, 377
  European corn borer committee, 25
  Executive committee report, 7
  Indices, 4
  International Congress delegates report, 29
  Journal Policy, Committee, 28, 1180
  Journal report, 4
  Members, xi
  Membership committee, 31
  Nomenclature report, 13
  Nominations committee, 33
  Officers, ix
  Pacific Slope Branch, 1009
  Permanent fund, 13
  Proceedings, 1
  Program committee, 24
  Resolutions committee, 30
  Secretary's report, 2
Eldred, D. N., 1031
elisus, Lygus, 1076

ellisiana, Dasyscypha, 622
Elm bark beetle, 48
  lace bug, 49
  leaf beetle, 46, 513
  pouch gall, 49
Elmore, J. C., 1095
Elsinoe canavaliae, 625
English, L. L., 987
Engraver beetle hibernation, 297
Entomological expenditures, 72
Entomological Program, Balancing, 39
  work, 695
Entomology building, 288
  4-H clubs, 680, 683
Eggplant leaf miner, 137
Ephialtes aequalis, 789
Epilachna corrupta, 115, 123
Epitrix cucumeris, 1175
  parvula, 233
Essig, E. O., 307, 735, 741, 864, 869, 1188
Ethylene-dichloride, 541
Eucosma gloriola, 49
Euetheola rugiceps, 973
eugenii, Anthonomus, 1095
Eulia velutinana, 335
Eumerus strigatus, 514
  tuberculatus, 514
euonymi, Chionaspis, 50
Euonymus scale, 50
Eupelmus cyaniceps, 652
European corn borer, 85, 196, 604, 747, 755, 893, 1171
  pine shoot moth, 48, 57
Eutettix tenellus, 1011
Ewing, K. P., 943
excrescens, Lecanium, 424
exitiosa, Aegeria, 903
Exobasidium oxycocci, 636
Extension entomologists, 668
  work, 677
Eyer, J. R., 846

Fabaceous plants, 587
fagi, Cryptophagus, 510
Farleman, M. G., 825
Farm machinery, 864
Farrar, M. D., 364
Faure, J. C., 706
fausta, Rhagoletis, 424, 825
Felt, E. P., 37, 45, 308, 424, 510, 977, 994, 995, 1183
femur-rubrum, Melanoplus, 103, 300, 669
festina, Stictocephala, 943
Ficht, G. A., 747
Fiorinia fioriniae, 50
fioriniae, Fiorinia, 50
Fir needle blight, 623
Fish meal, 720
Flanders, S. E., 511
Flannel moth, 295
flavescens, Cnidocampa, 54
flavoorbitalis, Cremastus, 95
Fletcher, F. W., 914
Fleury, A. C., 610
Flight trap insects, 1079
Flint, W. P., 39, 364
Florida red scale, 1177
Flotation method, 1175
Fluke, C. L., 514, 805, 1108
Fluorine compounds, 913, 1095
Fluorine insecticides, 996
Folsom, J. W., 934
forbesi, Cremastus, 790
Fracker, S. B., 641
Frankenfeld, J. C., 794, 799
Frankliniella californica, 836
Friend, R. B., 57, 115
Frost, S. W., 334
Fruit tree bark beetle, 48
frustrana, Rhyacionia, 49
Fulton, B. B., 513
fulvus, Desmoris, 652
furfura, Chionaspis, 912

Gaines, J. C., 274, 957, 963
Gaines, R. C., 940
Galerucella xanthomelaena, 46, 513
Galleria mellonella, 177
Gargaphia tiliae, 49
Garman, Philip, 330
Gas toxicity, 895
germanica, Blatella, 1083
Gersdorff, W. A., 451
Giant toad, 67
gifuensis, Macrocentrus, 95
Gilmore, J. U., 227
Ginsburg, J. M., 566
Gipsy moth, 47, 598
gladioli, Taeniothrips, 291, 523, 528, 536, 546, 555, 835
Gladiolus thrips, 291, 523, 528, 536, 546, 555, 835
Glasgow, Hugh, 431
glochinella, Gnorimoschema, 137
gloriola, Eucosma, 49
gloverii, Lepidosaphes, 988
Glypta rufiscutellaris, 789
Gnorimoschema glochinella, 137
  lycopersicella, 137
Gooden, E. L., 451
gossypii, Aphis, 453
Gracilaria azaleella, 634
Grain bin spray, 911
granarius, Sitophilus, 1033
Granary weevil, 1033
grandis, Anthonomus, 940, 1125
Graphium ulmi, 621
Graphocephala versuta, 943
Grapholitha molesta, 280, 774, 788, 982
  *See also* Laspeyresia
  prunivora, 509

Grasshopper control, 292, 494, 668
differential, 103
outbreak, 102
red-legged, 103
two-striped, 103
Grasshoppers, 300
Green, Don, 1021
Green June beetle, 46
Griswold, Grace H., 446, 720
gronovii, Cuscuta, 640
guttulatus, Scymnus, 859
Gwin, C. M., 997

Hallock, H. C., 80
Hamilton, C. C., 555
Hammer, O. H., 420
harknessii, Peridermium, 622
Harlequin cabbage bug, 129
Harman, S. W., 474, 516
Harris, H. M., 841
Hartzell, Albert, 583
Hartzell, F. Z., 474, 480
Headlee, T. J., 313, 606, 689
hederae, Aspidiotus, 632
Heliothis obsoleta, 109, 957, 978
virescens, 1175
Hemileuca oliviae, 794, 799
hemipterus, Carpophilus, 516
Hemlock leaf scale, 50
Hensill, G. S., 603
Herbert, F. B., 1052
Herrick, G. W., 446, 732
hesperus, Lygus, 1076
Hicock, H. W., 57
High, M. M., 912
Hill, L. L., 148
Hills, O. A., 906
Hinds, W. E., 758, 972
Hinman, F. G., 1063
Hippodamia ambigua, 1033
convergens, 1033
histrionica, Murgantia, 129
Hockenyos, G. L., 792, 1162
Hoffman, W. A., 294
Holloway, J. K., 280
Holloway, T. E., 974
Homalodisca triquetra, 943
Homotylus terminalis, 294
Honey bees, African, 998
Honey ripening, 188
Hopkins, C. O., 683
Hoplocryptus incertulus, 789
Hopper, T. H., 292
Horse fly trap, 301
Hough, W. S., 470
House fly, 486
Houser, J. S., 380
Howard, B. J., 918
Howard, N. F., 123, 914
Huber, L. L., 755
Hutson, Ray, 291, 425, 1171

Hydrocyanic acid gas, 259, 1031
Hylemyia cilicrura, 910
Hylobius pales, 218
Hyperaspis lateralis, 858
8-notata, 298
Hypermallus villosus, 48
Hyslop, J. A., 692

Idecthis nigrocoxalis, 789
idius, Ceratophyllus, 293
Inareolata punctoria, 95
incertulus, Haplocryptus, 789
Insect blood coagulation, 1083
collections, 14
pests, 692
populations, 873, 906
tolerance, 1016
trap, flight, 1079
Insects and agriculture, 869
Insecticides, 687, 689
insidiosus, Orius, 528
"Interval shooting," 262
invitus, Lygus, 62, 148
Ips hibernation, 297
oregoni, 733
iridis, Bregmatothrips, 916

Janes, M. J., 1011
Japanese beetle, 46, 205, 299, 405, 411, 632
japonica, Popillia, 46, 205, 299, 405, 411, 632
javanica, Chaetexorista, 56
Jewett, H. H., 1135
Johannsen, O. A., 308
johnsoni, Oencyrtus, 135
Jones, E. W., 887
Jones, G. D., 680
Jones, H. A., 451
Jones, R. M., 895
Jones, T. H., 513
Jones, W. W., 296
Journal proposals, 1180, 1183

Keen, F. P., 298
Kerosene extractives, 252
Kessels, L. T., 1179
Keifer, H. H., 293, 509
Knowlton, G. F., 730, 977, 995, 1011
Kuwana, S. I., 1185

Lachnopus curvipes, 1172
Ladybird beetles, 1031
Laetilia coccidivora, 50
Langford, G. S., 135
Larch canker, 622
case bearer, 46
laricella, Coleophora, 46
Larson, A. O., 1063
Lasioderma serricorne, 259, 294
Laspeyresia molesta, 334
*See also* Grapholitha

lateralis, Hyperaspis, 858
Leaf puncture resistance, 1135
Lecanium excrescens, 424
Lehman, R. S., 243
Leonard, M. D., 67
Leopard moth, 48
Lepidosaphes beckii, 988
  gloverii, 988
  newsteadi, 424
  ulmi, 477
Leptinotarsa decemlineata, 1068, 1174
Leptomastidea abnormis, 857
leucopterus, Blissus, 994
ligustici, Otiorhynchus, 731
Lilly, J. H., 514, 805
Lima bean scab, 625
Lime-sulfur, 730, 989
Limonius californicus, 1042
  canus, 243
Linden lace bug, 49
Lindorus lophanthae, 858
liriodendri, Toumeyella, 50
List, G. M., 373
Lixophaga variabilis, 603
Lizards, 1011
Lonchocarpus, 587
longispinosus, Pseudococcus, 1171
Lopez, Alonzo William, 306
lophanthae, Lindorus, 858
Lophodermium rhododendri, 637
Lubricating oil emulsion, 912
lugubre, Calosoma, 797
Lupinine, 500
lycopersicella, Gnorimoschema, 137
Lygidia mendax, 478
Lygus elisus, 1076
  hesperus, 1076
  invitus, 62, 148
  pratensis, 943
Lyle, Clay, 695, 973

MacLeod, G. F., 62
Macrocentrus ancylivorus, 280, 330, 986
  delicatus, 790, 982
  gifuensis, 95
macrotricha, Pestalotia, 638
maculatus, Trimeromicrus, 652
Mail, G. A., 1068
Maple bladder gall, 50
marinus, Bufo, 67
Marvin, G. E., 170
Masicera senilis, 95
Mason, H. C., 123
Maughan, F. B., 143
May beetles, 831
McAlister, L. C., 221
McCubbin, W. A., 625
McDaniel, E. I., 835
mcdanieli, Tetranychus, 425
McGarr, R. L., 943, 953
McGovran, E. R., 911
McLean, H. C., 727
Mealybug, long-tailed, 1171
Medical Entomology, 308
Megalopsallus atriplicis, 953
Megalopyge bissesa, 295
Meier, F. C., 653
Melanoplus bivittatus, 103, 669
  differentialis, 103, 494, 609
  femur-rubrum, 103, 300, 669
  mexicanus, 103, 669, 706
  packardii, 104
Melampsoropsis piperiana, 636
mella, Tachina, 797
mellea, Armillaria, 640
mellitor, Microbracon, 652
mellonella, Galleria, 177
Mercuric chloride, 542
Merritt, J. M., 580, 788
Metcalf, C. L., 510, 1182
Methyl anabasine, 500
Metriona bivittata, 151
Metzger, F. W., 205, 297, 300, 411
mendax, Lygidia, 478
Mexican bean beetle, 115, 123
mexicanus, Melanoplus, 103, 669, 706
Microbracon mellitor, 652
Microorganism odors, 516
Millettia, 587
minima, Pucciniastrum, 635
minor, Cremastus, 790
minutum, Trichogramma, 402, 758, 768, 974, 978
molesta, Grapholitha, 280, 774, 788, 982
  Laspeyresia, 334
mollipes, Draeculacephala, 282
monticolae, Dendroctonus, 733
montrouzieri, Cryptolaemus, 856, 1033
Moore, William, 1140
Moore, Warren, 723
Morofsky, W. F., 831
Mosquito larvae, 500
Motor oil, worn, 511
multistriatus, Scolytus, 48
Munger, Francis, 438
Murgantia histrionica, 129
Musca domestica, 486
myops, Oberea, 633
Myzus cerasi, 476

Names, insect, 1169
Nantucket pine moth, 49
Naphthalene, 143, 446, 512, 541, 558
Narcissus bulb nematode, 613
National Research Council, 9
nebulosus, Scymnus, 859
Nectria coccinea, 510
Nelson, R. H., 528, 546
nemorata, Phyllotoma, 732
nenuphar, Conotrachelus, 415
Newcomer, E. J., 572, 880, 1056
newsteadi, Lepidosaphes, 424

Nicotine, 500
Nicotine fixation, 723
Nicotine tannate, 1137
nigrocoxalis, Idecthis, 789
nitida, Allorhina, 46
North, H. F. A., 1117
Nougaret, R. L., 739
nubilalis, Pyrausta, 85, 196, 604, 747, 755, 893, 1171

Oak pruner, 48
Oberea myops, 633
obliteratus, Dioctes, 790
obsoleta, Calosoma, 797
Heliothis, 109, 957, 978
obsoletus, Crypticus, 911
ocellana, Spilonota, 477
ocellatus, Pristomerus, 790
octonotata, Hyperaspis, 298
Oil emulsions, 334, 566
films, 1023
on citrus, 1021
oleae, Saissettia, 1016
oliviae, Hemileuca, 794, 799
Oncometopia undata, 943
Onion leaf miner, 515
thrips, 143
Ooencyrtus johnsoni, 135
operculella, Phthorimaea, 135, 1173
oregoni, Ips, 733
Oriental beetle, 80
fruit moth, 280, 334, 774, 788, 982
moth, 54
roach, 792
orientalis, Anomala, 80
Blatta, 792, 1162
Phyllopertha, 633
Periplaneta, 1083
Orius insidiosus, 528
Ormocarpum, 587
ornatus, Dendrothrips, 47
Osterberger, B. A., 758
Otiorhynchids, 1172
Otiorhynchus ligustici, 731
oxycocci, Exobasidium, 636
Oyster shell scale, 477

packardii, Melanoplus, 104
Paddock, F. B., 177
pales, Hylobius, 218
Paradichlorobenzene, 555
Parasitus sp., 733
Paratenodera sinensis, 51, 1075
Paratetranychus pilosus, 335
Paratrioza cockerelli, 730, 846, 977
Parharmonia pini, 49
Park, O. W., 188
Parker, J. R., 102
Parker, W. B., 718
Parlatoria pergandii, 988
Parrott, P. J., 358, 368, 474
Patch, E. M., 921
Patch, L. H., 196
Pea weevil, 1058, 1063
Peach borer, 903
Pear psylla, 478
Pearson, A. M., 269, 486, 668
Peirce, L. L., 196
pellucida, Camnula, 104
Pepper weevil, 1095
pergandii, Parlatoria, 988
Peridermium harknessii, 622
Periplaneta americana, 1162
orientalis, 1083
perniciosus, Aspidiotus, 470, 476, 1016
Pestalotia macrotricha, 638
Petroleum spray oils, 735
phaseoli, Trifidaphis, 509
philadelphica, Calligrapha, 47
Phillips, E. F., 155
Phipps, C. R., 344, 349, 920
Phlegethontius quinquemaculata, 227
sexta, 227
Phomopsis leaf spot, 638
Phony peach disease, 659
Phorocera claripennis, 797
Phthorimaea operculella, 135, 1173
Phyllocoptes quadripes, 50
Phyllopertha orientalis, 633
Phyllophaga sp., 831
Phyllosticta spp., 636
Phyllotoma nemorata, 732
Physarum cinereum, 640
Phytophthora cactorum, 638
cinnamomi, 639
piceus, Attagenus, 446
picipes, Rhabdopterus, 632
pilosus, Paratetranychus, 335
Pimpla conquisitor, 797
Pine blister rust, 641
leaf scale, 989
oils, 1112
tip beetle, 994
pini, Parharmonia, 49
pinifoliae, Chionaspis, 989
piperiana, Melampsoropsis, 636
pisorum, Bruchus, 1058, 1063
Pitch mass borer, 49
Pityophthorus pulicarius, 994
Plagiodera versicolora, 46, 513
Plant Board, Central, 610
Western, 610
Plum curculio, 415
Polivka, J. B., 755
pomaria, Typhlocyba, 325
pometaria, Alsophila, 1030
pomonella, Carpocapsa, 358, 364, 373, 380, 383, 392, 438, 1016, 1056, 1112
Rhagoletis, 221, 344, 349, 825, 1108
Poos, F. W., 648
Popillia japonica, 46, 205, 299, 405, 411, 632

Porthetria dispar, 47
Potato beetle, Colorado, 1068
  flea beetle, 1175
  psyllid, 846, 977
  stalk borer, 1173
  tuber moth, 1173
  tuber worm, 135
  wart, 649
pratensis, Lygus, 943
Pratt, F. S., 1031
Price, W. A., 595
Prepodes roseipes, 1172
Pristomerus ocellatus, 790
Privet thrips, 47
Propylene dichloride, 291, 893
Protocalliphora splendida, 293
Protoparce sexta, 1175
prunivora, Grapholitha, 509
pruniella, Coleophora, 513, 805
Psallus seriatus, 943, 963
Pseudaonidia duplex, 988, 1177
Pseudococcus citri, 855
  longispinosus, 1171
pesudomagnolarium, Coccus, 298
pseudotsugae, Dendroctonus, 733, 1128
Psyllia pyricola, 478
Ptinus tectus, 734
Pucciniastrum minima, 635
pulicarius, Pityophthorus, 994
punctatissimus, Corthylus, 47
punctoria, Inareolata, 95
pusilla, Agromyza, 515
Pyrausta nubilalis, 85, 196, 604, 747, 755, 893, 1171
Pyrethrin, 997
Pyrethrum, 252, 914, 1171
Pyrethrum fields, 583
pyricola, Psyllia, 478
pyrina, Zeuzera, 48

quadrigibbus, Tachypterellus, 420
quadrimaculatus, Xylotrechus, 977
quadripes, Phyllocoptes, 50
Quarantine, 595, 606
Quayle, H. J., 288, 1182
quinquemaculata, Phlegethontius, 227

Radio waves, 313
Range caterpillar, 794, 799
rapidus, Adelphocoris, 943
Raspberry mites, 425
Recurvaria apicitripunctella, 47
Red clover, 1135
  scale, 851, 1016
Refrigerated shipments, 280
Rehmeillopsis bohemica, 623
Rhabdopterus picipes, 632
Rhagoletis cingulata, 431, 825
  completa, 813, 819
  fausta, 431, 825
  pomonella, 221, 344, 349, 825, 1108
  tabellaria, 437
Rhizobius ventralis, 858
Rhizopertha dominicana, 293
Rhizotonia solani, 639
rhododendri, Cercospora, 635
  Lophodermium, 637
  Sesia, 633
Rhododendron lace bug, 631
  thrips, 632
Rhyacionia buoliana, 48, 57
  frustrana, 49
Rice, P. L., 1079, 1083
Richardson, C. H., 269, 486, 494
Richardson, H. H., 252, 536, 546, 915, 995
Richmond, R. G., 194
Riley, W. A., 308
Roaches, 1162
Roark, R. C., 587
Robey, O. E., 580
Rocky mountain locust, 706
Rolfs, A. R., 1056
roseipes, Prepodes, 1172
Rosenfeld, A. H., 1172
roseus, Aneuraphis, 475
Rotenone, 587
Rotenone toxicity, 451
rufiscutellaris, Glypta, 789
rugiceps, Euetheola, 973
rugulosus, Scolytus, 48
Rust, H. J., 734

saccharalis, Diatraea, 758, 974
Saissettia oleae, 1016
salicata, Corythucha, 1090
Salt, R. W., 1068
Sample collecting, 906
San Jose scale, 470, 476, 511, 732, 1016
Satterthwait, A. F., 210
Schistocerca americana, 300, 692
Schizonotus sieboldi, 513
Schoene, W. J., 325
Schread, J. C., 402
Scolia dubia, 46
Scolytus multistriatus, 48
  rugulosus, 48
Scurfy scale, 912
Scymnus bipunctatus, 858
  guttulatus, 859
  nebulosus, 859
  sordidus, 859
Seed corn maggot, 910
Segal, Bernard, 302
Semesan, 542
semiflavidus, Anastatus, 797, 799
senilis, Masicera, 95
Septoria azaleae, 637
seriatus, Psallus, 943, 963
serricorne, Lasioderma, 259, 294
Sesia rhodendri, 633
setiger, Calendra, 210
sexta, Phlegethontius, 227
  Protoparce, 1175

Shade tree insects, 45
Sheals, R. A., 641
Shepard, H. H., 913, 998
Sherman, Franklin, 383
Shropshire, L. H., 675
Shull, W. E., 1076, 1083
sieboldi, Schizonotus, 513
Siegler, E. H., 438
Sim, R. J., 297
sinensis, Paratenodera, 51, 1075
Sitophilus granarius, 1033
Sitotroga cerealella, 402, 510, 769
Smith, C. E., 911
Smith, F. F., 523, 528, 536, 916
Smith, R. H., 731
Smyth, E. G., 768
Snapp, O. I., 512, 733
Sodium fluoride, 1162
Soil insecticides, 580
solani, Rhizoctonia, 639
sordidus, Scymnus, 859
Souring figs, 917
Spies, J. R., 285
Spilonota ocellana, 477
splendens, Chrysoplatycerus, 858
splendida, Protocalliphora, 293
Sporocybe azaleae, 639
Spray oils, evaporation, 735
  residues, 727
  service, 675
  tank agitation, 1106
Spruijt, F. J., 515, 613
Stable fly, 269
Stanley, W. W., 300
Stear, J. R., 903
Stearns, L. A., 151
Steiner, L. F., 774
Stem rust, 653
Stephanitis pyrioides, 631
Stictocephala festina, 943
Stockwell, C. W., 405
Stomoxys calcitrans, 269
Stone, M. W., 237
strigatus, Eumerus, 514
Sugarcane beetle, 973
Sugar cane borer, 758, 972, 974
sulcatus, Brachyrhinus, 47, 634
Sulfur, flowers of, 1023
Sullivan, W. N., 451, 500
Summers, J. N., 51
Sunflower weevil, 652
Surface oil determination, 1021
Swain, A. F., 1021, 1031
Sweet potato beetle, 151
Sweetman, H. L., 320
Sycamore lace bug, 49
sycophanta, Calosoma, 797
Sympherobius angustus, 859
  barberi, 859
  californica, 859
tabaci, Thrips, 143
tabellaria, Rhagoletis, 437
Tachina mella, 797
Tachypterellus quadrigibbus, 420
Taeniothrips gladioli, 291, 523, 528, 536, 546, 555, 835
Tar distillates, 470, 474, 480
  oil emulsions, 912
Tarnished plant bug, 62, 148
Tartar emetic, 227
Tate, H. D., 516, 841, 1173
tectus, Ptinus, 734
telarius, Tetranychus, 633
Temperature, 1068
tenellus, Eutettix, 1011
terminalis, Homotylus, 294
teterellus, Crambus, 1117
Tetranychus mcdanieli, 425
  telarius, 633
Thomas, C. A., 137
Thompson, B. G., 1090
Thompson, F. M., 1112
Thompson, G. A., 1117
Thomson, J. R., 512, 733
Thrips tabaci, 143
Thrips, western flower, 836
Thurber, G. A., 494
Thylodrias contractus, 509
tiliae, Gargaphia, 49
Tineola bisselliella, 446
Tingid, western willow, 1090
Tobacco beetle, 259
  budworm, 1175
  flea beetle, 233
  hornworm, 227
Tomato pin worm, 137
  worm, 1175
Toumeyella liriodendri, 50
Toxicity, gases, 895
  Plant Extracts, 285
  relative, 500
Toxicological studies, 438
Trialeurodes vaporariorum, 453
Trichobaris trinotata, 1173
Trichogramma minutum, 402, 511, 758, 768, 974, 978
Trifidaphis phaseoli, 509
Trimeromicrus maculatus, 652
trinotata, Trichobaris, 1173
triquetra, Homolodisca, 943
Trisodium arsenite, 486
Tropical Plant Research Foundation, 12
tsugae, Aspidiotus, 424
tuberculatus, Eumerus, 514
Tulip tree, nectar, 170
  tree scale, 50
Turner, Neely, 115
Turner, W. F., 659
Turnipseed, G. F., 987
Tylenchus dipsaci, 613

Typhlocyba comes, 719
pomaria, 325

Ulman, P. T., 610
ulmi, Corythucha, 49
Graphium, 621
Lepidosaphes, 477
undata, Oncometopia, 943

Vacuum fumigation, 259
valens, Dendroctonus, 828
Vansell, G. H., 168
Vapo-Dust, 718
vaporariorum, Trialeurodes, 453
Vapor-Heat, 613
variabilis, Lixophagus, 603
Varietal resistance, 62
Vegetable insect scouting, 672
velutinana, Eulia, 335
ventralis, Rhizobius, 858
verbasci, Anthrenus, 446
Chlamydatus, 1173
versicolora, Plagiodera, 46, 513
versuta, Graphocephala, 943
villosus, Hypermallus, 48
virescens, Heliothis, 1175

Walker, H. G., 129, 677
Walnut husk fly, 813, 819
Walther, Eric, 828
Watkins, W. G., 168
Weber, A. L., 727
Webster, R. L., 1016
Webworms, bluegrass, 1117
Weevil cage, 176
Weigel, C. A., 523
Whitcomb, W. D., 415
White fly, 453
Whitehead, W. E., 293
White pine tip moth, 49
White, R. P., 631
Wildermuth, V. L., 794
Wildman, J. D., 517
willkommii, Dasyscypha, 622
Willow leaf beetle, 46, 513
Wilson, J. L., 269
Wireworms, 237, 243, 887, 1042
Wolcott, G. N., 1173
Woodgate rust, 622
Wong, K. L., 1090
Worthington, A. D., 668
Worthley, H. N., 1112
Worthley, L. H., 85, 405

xanthomelaena, Galerucella, 46, 513
Xylotrechus quadrimaculatus, 977

Yellow dwarf, onion, 841
Yetter, W. P., 774
York, H. H., 218

Zeuzera pyrina, 48

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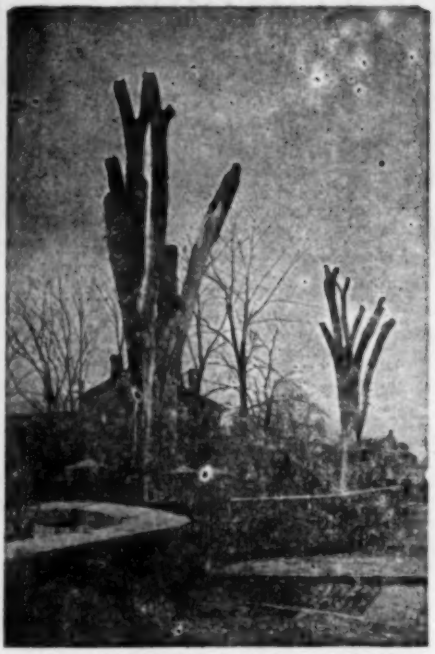

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